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US Army Corps of Engineers
Hydrologic Engineering Center

GENERALIZED COMPUTER PROGRAM

DAMCAL

Damage Reach Stage-Damage Calculation

User's Manual

February 1979

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CPD-35

DAMAGE REACH STAGE-DAMAGE CALCULATION
(DAMCAL)

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Introduction

The DAMCAL (damage reach stage-damage calculation) computer program documented in this section is part of a family of computer programs, which includes the HYDPAR program discussed previously in Section 3, that make up the Spatial Data Management and Comprehensive Analysis System. These programs are part of an ongoing effort to provide a systematic and comprehensive technique for managing and analyzing spatial data for use in water resources management investigations.

The DAMCAL program, like HYDPAR, is designed to access data and information stored in a grid cell data bank similar to the one developed for the Trail Creek Watershed (U.S. Army Corps of Engineers, 1975). The particular methods used in storing and accessing spatial data (or information) which are utilized by this computer program are described in a guide manual available from the Hydrologic Engineering Center (U.S. Army Corps of Engineers 1978).

An overview of the programs requirements and capabilities are presented herein. In addition, the input necessary for program execution and related output are described in detail for the benefit of the user. Sample input and output has also been included to demonstrate the capabilities of the system and as a data set for testing the computer program.

The DAMCAL program is maintained and distributed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, 609 Second St., Davis, California, 95616. This agency should be contacted for any questions regarding its use or availability.

Overview

Water resource planners are charged in the plan formulation process to evaluate a broad range of alternative flood damage reduction measures that will provide flood damage relief for existing and future land use conditions. The plan formulation process requires developing alternative means for accomplishing performance targets and selecting from those alternatives the ones which are the most attractive. This necessitates the systematic assessment of the economic value of the proposed alternatives. In such cases it is desirable that alternatives be compared quickly, with the comparisons based on an adopted and consistent methodology.

Spatial analysis methods provide the mechanism for expedient and consistent economic evaluation of alternative flood damage reduction measures. The methods used include the evaluation of geographic information which has been digitized and stored in computer files in digital form. Each geographic data variable is encoded separately and a registered grid cell representation of each data variable is stored in a sequential grid cell record as a part of the DATA BANK.

The geographic data variables that are used to perform the damage analysis are: 1) topographic elevation, 2) reference flood elevation, 3) damage reach delineation, 4) existing land use classification, and 5) alternative future land use patterns. Each alternative analysis utilizing the DAMCAL program results in the creation of an aggregated elevation-damage function for each land use category at each damage reach index location. The functions may be analyzed conventionally by damage-frequency integration methods or used as input into more complex system formulation models, such as the ATODTA-HEC-1 linkage (described in Section 5 of this document).

The DAMCAL computer program accesses the geographic information stored in a grid cell DATA BANK for the evaluation of 1) the existing land use condition and 2) any number of future land use conditions or specific land development proposals. A powerful analytical capability in the DAMCAL program is the

ability to evaluate nonstructural alternatives such as flood plain management policies, flood proofing alternatives (raising structures, levees, the addition of flood proofing materials to structures, etc.), permanent evacuation of structures in the flood plain, temporary structural protection and content removal in response to flood warnings, and any combination of the preceding. The alternatives may be evaluated in terms of providing a target protection level (such as protection from the 100-year flood event) or in providing uniform land use category protection (for example, flood proofing industrial structures to a height four feet above existing ground elevation). Table 4-1 summarizes the functional capabilities of the DAMCAL program.

TABLE 4-1

DAMCAL ANALYSIS CAPABILITIES

	Land Use Pattern		
			Alternative Future
Alternatives	Existing	Alternative Future	New Development Only
Do Nothing (Without Condition)	X	X	
Structural Flood Control Measures	X	X	
Uniform Flood Proofing of a Specified Land Use Category	X	X	X
Uniform Flood Protection of a Damage Reach	X	X	X
Temporary Evacuation	X	X	
*Permanent Evacuation	X	X	X
*Flood Plain Regulation	X	X	X

X *Indicates analytical capability*

* Evaluations may be made for structures in the flood plain and for structures which have their zero damage elevation in the flood plain.

Input Limitations. As in the case of the HYDPAR program, the input requirements for DAMCAL are designed so that individual user data input requirements can be accommodated as much as possible. Thus a dynamic array similar to one used in the HYDPAR program has been written into DAMCAL to allow a certain degree of flexibility in the selected number of data variables, land use categories, damage reaches and elevations for the stage-damage computations. In general, the number of land use categories and damage reaches will be the limiting variables in the dynamic array.

The limits on data input for the DAMCAL program are given below:

Input	Variable
Number of Damage Reaches	NODR
Number of Land Use Categories	NOLUC
Number of Elevations for the Elevation-Damage Relationship	IELV
Number of Single Flood Events	ITYPE
Number of Data Variables in the Grid Cell Data Bank	NDV

$$x = (IELV + ITYPE) * NOLUC * NODR \qquad (4\text{-}1)$$

x *cannot exceed 122,000*

$$z = 37(NODR) + 78(NOLUC) + IELV(NODR + 1) + 4(NOLUC)(NODR) + NDV \qquad (4\text{-}2)$$

z *cannot exceed 23,000*

Hardware and Software Requirements. The DAMCAL program was developed using a CDC 7600 computer at the Lawrence Berkeley Laboratory, University of California, Berkeley, California. In general it is compatible with other major computer systems. (Difficulties in installation should be reported to the Hydrologic Engineering Center).

Program Language:	FORTRAN IV (ANSI standard)
Memory Requirement (limit):	470,000 words (octal) of core (word size - 60 bits)
Special Library Functions:	None
Printer Positions:	132
Tape Assignments: Tape 1:	Grid cell data bank
Tape 2:	Single event damages
Tape 5:	Standard card input
Tape 6:	Standard line printer
Tape 20:	File that may be saved or passed to ATODTA (ATODTA included in Section 5 of this document)
Storage Devices (permanent):	3 magnetic tapes or disk file units

Specific Capabilities

Methods of computing the flood damage potential of a stream system require the development of elevation-damage functions at selected damage reach index locations throughout the system. The elevation-damage functions are then integrated with hydrologic flow-frequency and flow-elevation data to compute the value of expected annual damage (U.S. Army Corps of Engineers 1977). Damage reaches are defined to capture economic and hydrologic variation that occur in the system. Usually elevation (or stage)-damage relationships are developed for each individual structure, the associated value of the contents, and an optional damage category called "other" within the damage reach of interest. The damage functions are then aggregated to an index location by adjusting elevation related data to account for the slope of the water surface profile in a particular reach.

The technique developed for automatically generating elevation-damage functions in the DAMCAL computer program adapts the traditional method to grid cell data bank concepts. The methodology, in general, consists of constructing a unique elevation-damage relationship for each grid cell within the flood plain based on topographic data (ground elevations) and land use, and

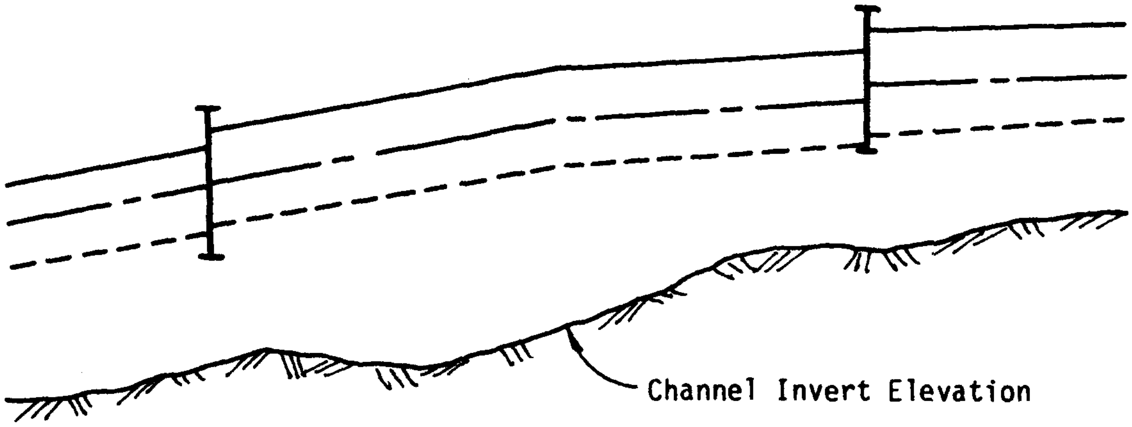
then aggregating the damage potential of all grid cells assigned to a particular damage reach to an appropriate index location.

Damage Reaches. Damage reach boundaries are selected based on a procedure of determining reaches with consistent parallel water surface profiles for a range of discharges while maintaining the economic detail desired for analysis. The lateral boundaries extend a reasonable distance from the stream to the edge of the flooded area of the largest flood event deemed necessary for economic-damage evaluations, plus an additional horizontal increment to insure coverage of proposed and future conditions (Figure 4-1 illustrates typical damage reach delineations). The damage reaches are encoded into the grid cell data bank and each cell within a particular reach is assigned a damage reach identification value or code. The damage reach identification is then used to insure that the grid cells are aggregated with respect to the appropriate damage reach index location.

Reference Flood. Since a flood profile yields different water surface elevations throughout a damage reach, a representative (or reference) flood event is required to properly adjust the topographic (or first floor) elevation of each grid cell for aggregation purposes within a particular reach (with respect to the index location). Each cell is assigned a reference flood water surface elevation which is used with the reference flood elevation at the index location to adjust the individual damage functions (for proper aggregation of damages at the index location).

The reference flood should be an event within the range which is critical for flood damage computation, a mid-range flood event (a 25 to 50 year event) is often more appropriate than a rare flood with a 500-year exceedance interval. Historic flood events are often used as reference floods. If the flow profiles for different discharge rates are consistently parallel throughout the potential damage range, the selection of the reference flood is not as critical. The reference flood elevations should be determined

WATER SURFACE PROFILES



DAMAGE REACH DELINEATION

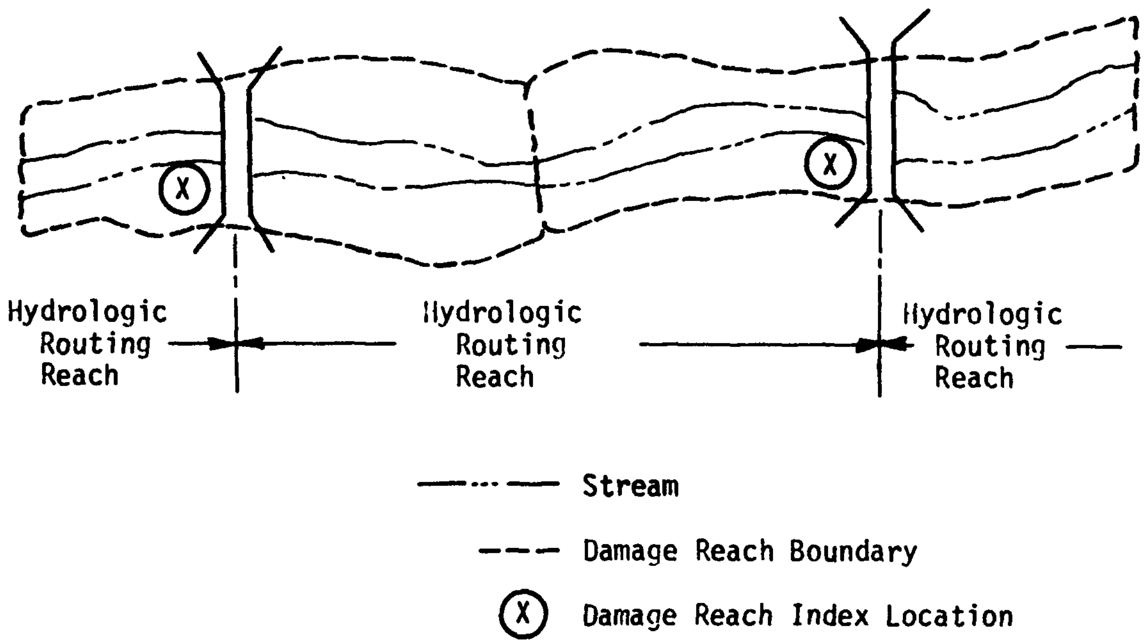


FIGURE 4-1

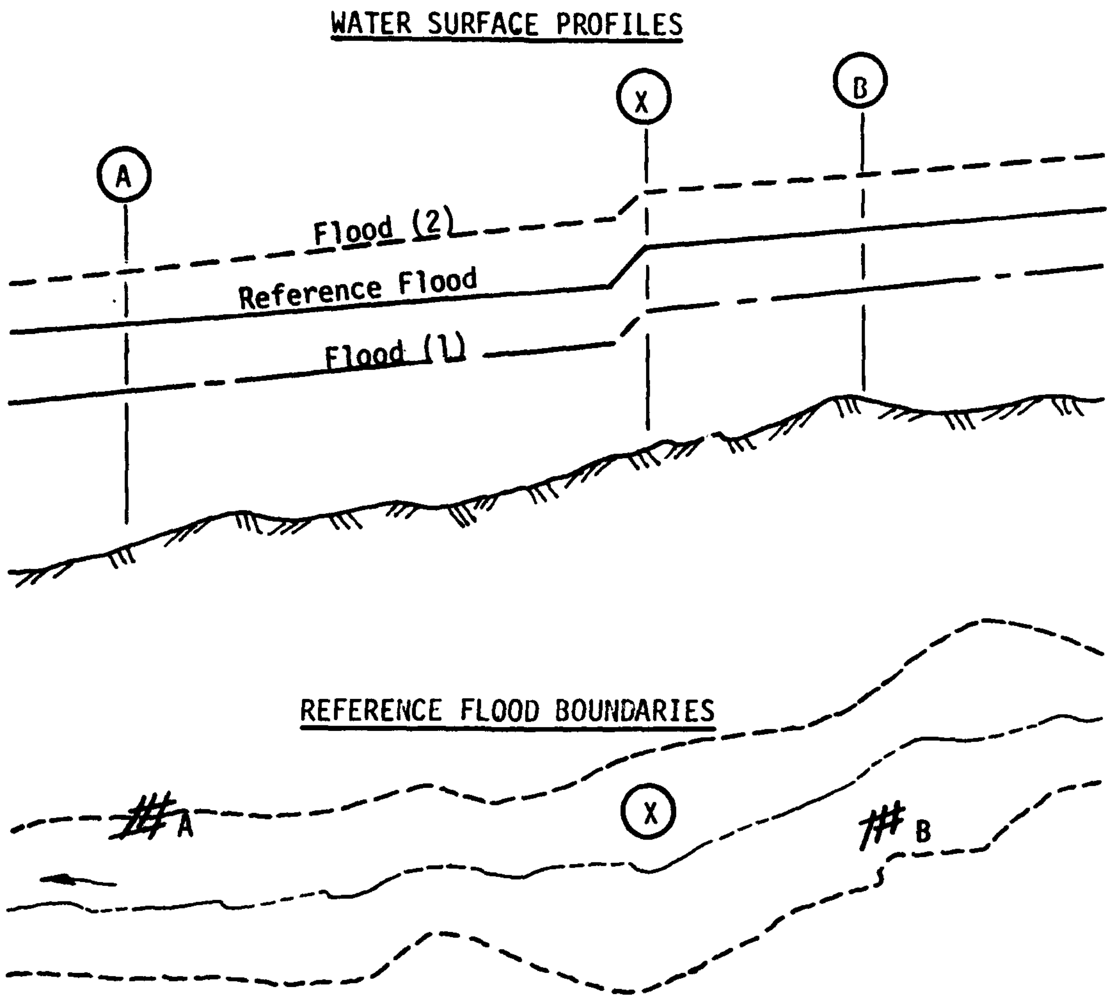
DAMAGE REACH DELINEATIONS

from good quality high water marks or detailed water surface profile analyses. Figure 4-2 illustrates the adjustments performed using the reference flood water surface elevations.

Composite Damage Functions. The general objective of the analytical methods developed is to provide a consistent and expedient methodology of evaluating a range of structural and nonstructural alternatives for existing and selected alternative future land use patterns. The concept of using generalized composite stage-damage relationships for the land use category assigned to each grid cell was selected as the mechanism to perform the analysis rather than the conventional individual structure approach alluded to previously. The use of the generalized functions provides the capability to evaluate expeditiously alternative land use patterns that are consistent with the existing (base) condition land use pattern.

A composite damage function is defined as a stage-damage function for a specified area within each adopted land use category that has significant damage potential. The functions may be developed for each land use category by averaging the structural and related content values obtained from sampling a range of structure values and types within each specified category (by utilizing field surveys, review of tax records, interviews conducted with regional and local agencies, etc.). The composite damage function can include direct and indirect damages associated with each particular land use category. Table 4-2 illustrates an example of a composite stage-damage function within a particular land use category. The functions can be developed for other land use categories such as pasture, developed open space, etc., although the corresponding damages are small when compared to those occurring in the structurally developed areas.

DAMCAL can be used to develop the composite stage-damage function for a specific land use category based on the following types of information:



\# Structure Locations

(X) Index Location

--- Boundary of Reference Flood

——·-·—— Stream

Reference Flood
Water Surface Elevations

Index location = 614.5

A = 610.0

B = 617.0

Damage Functions at A must be adjusted by adding 4.5 feet (614.5-610.0) before aggregating to the index location.

Damage Functions at B must be adjusted by subtracting 2.5 feet (614.5-617.0) before aggregating to the index location.

FIGURE 4-2

REFERENCE FLOOD CONCEPTS

TABLE 4-2

COMPOSITE STAGE-DAMAGE FUNCTION FOR
A PARTICULAR RESIDENTIAL LAND USE CATEGORY

Depth of Water	Percent Damage (Structure)	Percent Damage (Contents)	Amount of Damage Per Grid Cell (In Thousand Dollars)
-2.00	1.00	0.00	.24
-1.00	1.00	0.00	.24
0.00	10.00	2.00	2.48
1.00	13.00	33.00	5.02
2.00	20.00	54.00	7.91
3.00	27.00	66.00	10.28
4.00	30.00	73.00	11.40
5.00	33.00	77.00	12.34
6.00	35.00	80.00	12.99
7.00	36.00	81.00	13.29
8.00	40.00	81.00	14.23
9.00	41.00	81.00	14.47
10.00	41.00	81.00	14.47
11.00	45.00	81.00	15.42
12.00	45.00	81.00	15.42

Density of the land use (units per grid cell) = 1.50

Base value of the structure $20,000.00

Base value of the contents = $5,000.00

Vacancy factor (percent developed) = 75%

Indirect damages are 5.00 percent of the total grid cell dollar damage

- Stage versus % damage to structure
- Stage versus % damage to contents
- Value of structure
- Value of contents (option, % of structure value)
- Indirect damage (% of total grid cell dollar damage)
- Development density (number of structures per grid cell)
- Vacancy allowance (amount of land classified in the particular category that is developed)

Computational Procedures

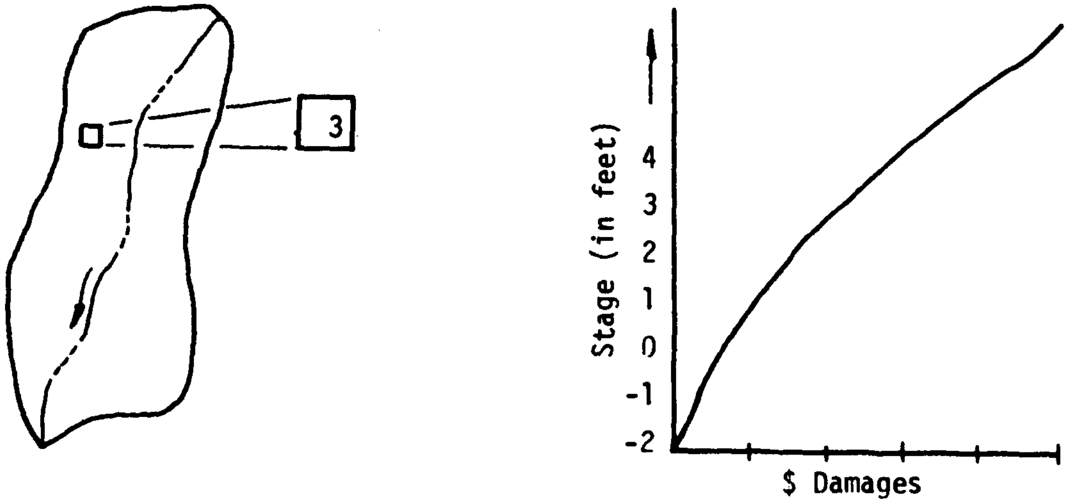
Aggregation of Damage Functions. The creation of an aggregated elevation-damage function for each damage reach index location can be done once the spatial data variables (topographic elevation, reference flood elevation, damage reach identification and land use patterns) are in the DATA BANK and composite damage functions have been developed for each land use category.

The DAMCAL computer program accesses the DATA BANK and for each grid cell in the flood plain manipulates the appropriate data in the following manner:

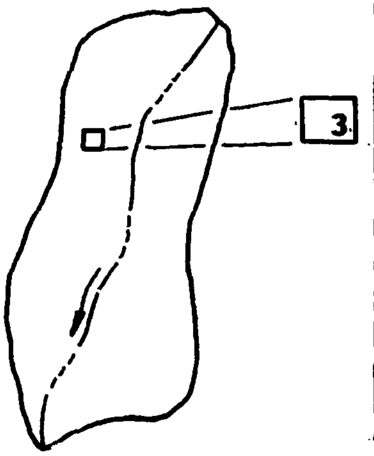
(1) The land use of the cell is determined and the corresponding composite stage-damage function is placed at the grid cell (Figure 4-3a).

(2) The stage axis of the function is converted to elevation by equating the zero stage to either ground elevation or first floor elevation. The conversion of stage to elevation completes the placement of the composite damage function at the grid cell (Figure 4-3b).

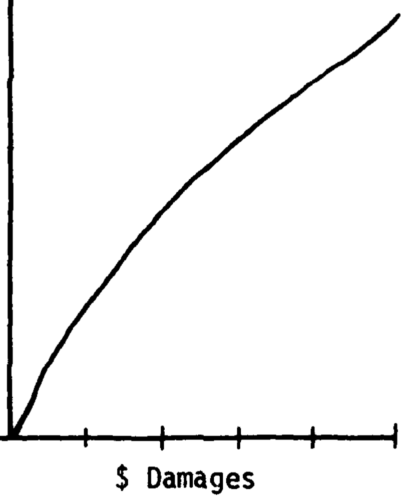
(3) The next step in the aggregation process is to transfer the grid cell elevation-damage function to the index location. The data bank is accessed to determine in which damage reach the cell is located and then the function is translated to the appropriate index location by adjusting the elevation axis of the damage function. The adjustment



(a) Land use 3 (low densitv residential) with the composite stage-damage function shown.



Stage	Elev	Elev* w/ 1st Floor
4	674	676
3	673	675
2	672	674
1	671	673
0	670	672
-1	669	671
-2	668	670



(b) The stage is converted to elevation based on the reference datum of the composite damage function.

* For land use 3 the first floor elevation is 2 feet above the ground elevation.

FIGURE 4-3

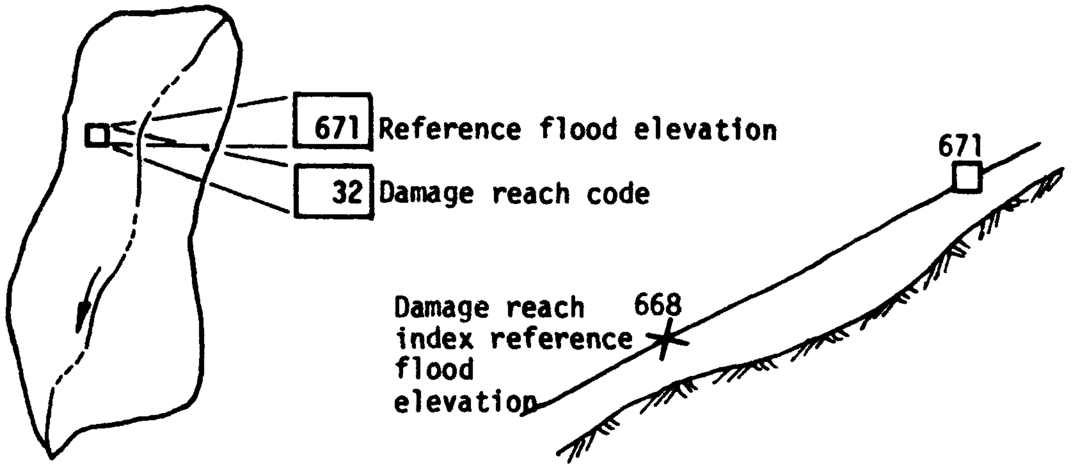
DEVELOPMENT OF A COMPOSITE ELEVATION-DAMAGE FUNCTION FOR A GRID CELL

is based on the difference between the reference flood water surface elevations at the grid cell and the index location. Figure 4-4 shows a grid cell upstream of the index location with a difference in reference flood elevations of 3 feet. In this case the elevations of the grid cell elevation-damage function (elevation-damage function in which the zero stage coincides with the first floor elevation) are reduced by 3 feet to complete the translation process.

(4) The resulting grid cell aggregated elevation-damage function (Figure 4-4) is then combined with the elevation-damage functions of other grid cells having the same land use category (land use 3) and which were previously aggregated to the index location (for damage reach 32). (Combined damage functions are separated based on land use categories so that damage calculations may be subdivided according to a particular interest). Figure 4-5 shows the aggregated damage potential of the sample grid cell being combined with the existing (aggregated) damage potential at the index location for land use 3.

If, for example, there are five land use categories in a particular damage reach and the damages for each grid cell in the reach have been aggregated to the index location, then a summary of the computed aggregated damage functions for the various land uses would appear as shown in Table 4-3. The total aggregated damage function (a summation of the individual functions) is also included.

The aggregation procedure described is the same for all DAMCAL runs, whether evaluating existing or alternative future conditions. The difference in the evaluation of nonstructural measures (described in the following paragraphs) is in the modification of the composite damage function or in the modification of the elevation axis of the elevation-damage function.



The damage reach code is used to locate the appropriate reference flood elevations in the aggregation process. The adjustment in this case is -3 feet (668-671).

Stage	Elev w/1st Floor	Elev Agg.to Index Location	$ Damages ($\times 10^3$)
4	676	673	7.0
3	675	672	5.0
2	674	671	3.6
1	673	670	2.0
0	672	669	1.2
-1	671	668	0.8
-2	670	667	0

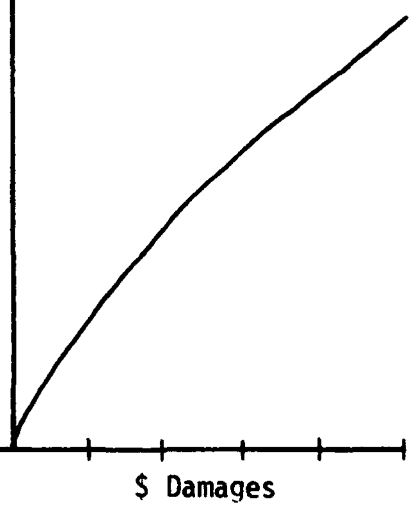


FIGURE 4-4

TRANSLATION OF THE GRID CELL ELEVATION-DAMAGE FUNCTION TO THE DAMAGE REACH INDEX LOCATION

Elev	$ Damages (x 10^3)
673	7.0
672	5.0
671	3.6
670	2.0
669	1.2
668	0.8
667	0

Grid cell's aggregated elevation-damage function

→

Elev	$ Damages (x 10^3)
673	41.0
672	37.4
671	35.0
670	20.3
669	17.6
668	14.2
667	12.3
666	10.7
665	5.2
664	4.7
663	1.1
662	0

Land use 3's aggregated elevation-damage function prior to the sample cell being combined

→

Elev	$ Damages (x 10^3)
673	48.0
672	42.4
671	38.6
670	22.3
669	18.8
668	15.0
667	12.3
666	10.7
665	5.2
664	4.7
663	1.1
662	0

Resulting aggregated elevation-damage function for land use 3 until another grid cell (in damage reach 32 and with land use 3) is combined

FIGURE 4-5

DAMAGE AGGREGATION PROCESS

TABLE 4-3

AGGREGATED DAMAGE-FUNCTIONS
FOR DAMAGE REACH 32
AT THE INDEX LOCATION

Elev	Existing Land Use*					
	1	3	6	7	9	Total
654	0.0	0.0	0.0	0.0	0.0	0.0
655	0.5	0.0	0.1	0.0	0.0	0.6
656	1.2	0.0	0.4	0.0	0.0	1.6
657	1.4	0.0	0.4	0.0	0.1	1.9
658	1.5	0.0	0.4	0.0	0.1	2.0
659	1.6	0.0	0.4	0.0	0.1	2.1
660	1.9	0.0	0.4	0.0	0.1	2.4
661	2.4	0.0	0.4	0.0	0.1	2.9
662	2.8	1.1	0.4	1.2	0.2	5.7
663	3.1	5.5	0.4	1.2	0.2	10.4
664	3.2	14.7	0.4	20.4	0.2	38.9
665	3.4	19.9	0.4	86.1	0.2	110.0
666	3.7	26.8	0.4	175.9	0.3	207.1
667	4.0	36.4	0.4	267.5	0.3	308.6
668	4.2	47.9	0.4	325.1	0.4	378.0
669	4.4	71.6	0.4	372.2	0.4	449.0
670	4.5	81.4	0.5	410.6	0.4	497.4
671	4.6	91.0	0.5	442.8	0.5	539.4

* Land Use Categories (Damages in thousands of dollars)

1 = Natural Vegetation

3 = Low Density Residential

6 = Agricultural

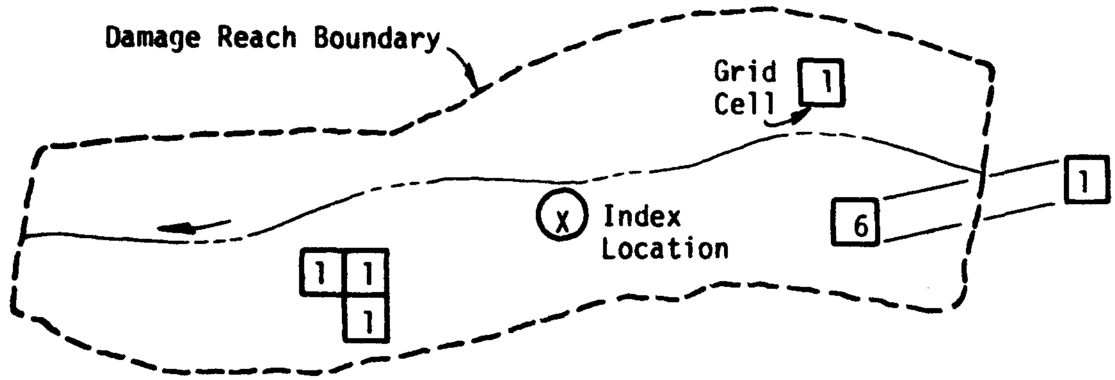
7 = Industrial

9 = Pasture

Nonstructural Measures

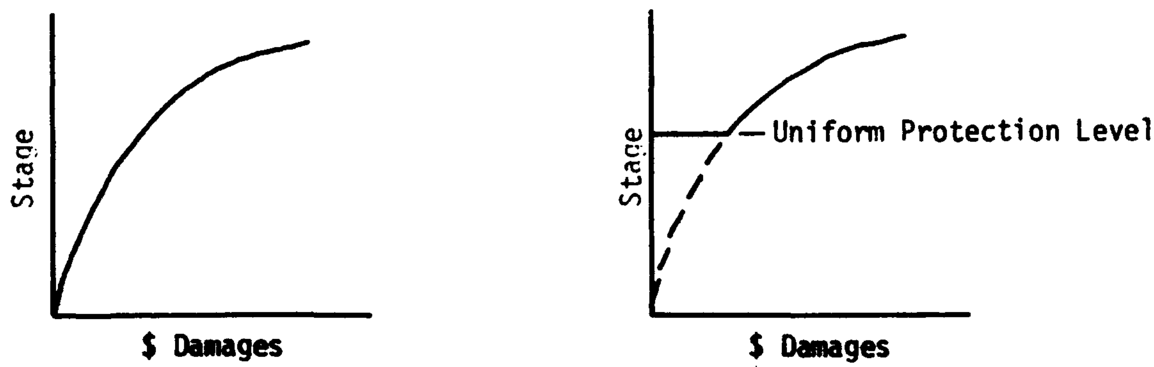
The evaluation of nonstructural flood damage reduction measures requires modification of the aggregated elevation-damage function, although a proposed measure may have little or no impact on the hydrologic response of the system (U.S. Army Corps of Engineers 1977). The DAMCAL computer program used to construct elevation-damage functions at damage reach index locations for existing and alternative land use patterns (as described in the preceding paragraphs) is also used in developing the damage functions for nonstructural measures. The types of nonstructural alternatives for which elevation-damage functions can be constructed are: 1) flood proofing specified land use categories a given number of feet above or below ground or first floor level (zero stage datum), 2) flood proofing specified land use categories to a uniform flood protection level, 3) temporary protection of structures and evacuation of contents in response to flood warning disseminations, 4) permanent relocation of structures within flood prone areas, and 5) regulatory policies restricting development in the flood plain. Each of the nonstructural alternatives is evaluated by modifying the appropriate land use category composite stage-damage function and/or the elevation-damage function of the grid cells affected.

Uniform Flood Proofing of a Land Use to a Specified Stage. The flood proofing of selected land use categories to specified stages results in the protection of all grid cells of the designated land use categories to predetermined heights. The assessment of potential flood damage reduction resulting from uniform flood proofing of this type is accomplished by directly modifying the input composite stage-damage function (see Table 4-2) or automatically (through the DAMCAL program) truncating the composite stage-damage function at the appropriate level. Figure 4-6 illustrates and describes the method used to perform the flood proofing assessment. As an example, consider the evaluation of flood proofing future development only. In a very simple land use alternative (used for purposes of clarity) the grid cell classified as land use 6 (existing or base condition) is converted



NOTE: Only selected grid cells are shown for clarity but in application the grid cells are exhaustive for the entire reach

COMPOSITE DAMAGE FUNCTIONS (Land Use Category 1)



Base Condition　　　　Modified Condition

GENERAL PROCEDURE FOR FLOOD PROOFING OPTION

1. If a uniform protection level is designated for land use category 1, then the composite damage functions of all grid cells assigned land use 1 are truncated to the specified protection level as shown. (It should be noted that the process could be repeated in the flood proofing of other land use categories).

2. An elevation-damage curve is then developed for each grid cell in the damage reach using the adopted and modified composite damage functions and assigning topographic elevations to the various stages (in the case of grid cell 1 the composite damage function would be the modified or truncated condition).

3. The elevation-damage curves are then adjusted based on the difference in reference flood elevations between individual grid cells and the index location and then aggregated according to land use classification.

FIGURE 4-6

FLOOD PROOFING SELECTED LAND USE CATEGORIES

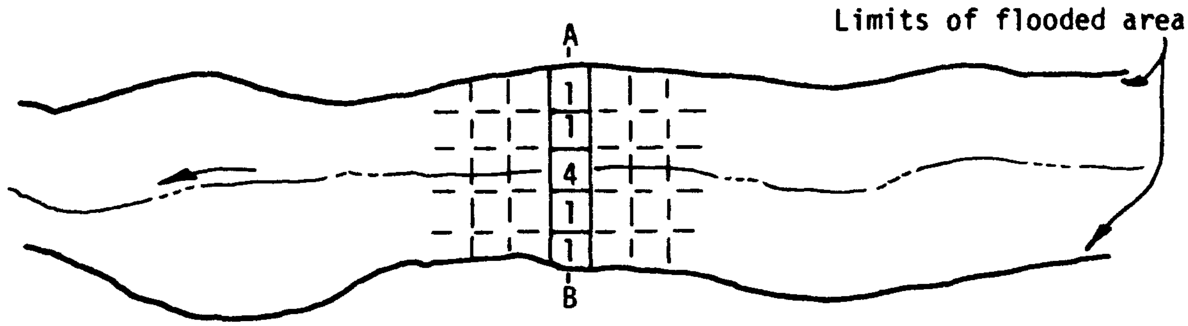
to land use 1 (future condition). In the aggregation process associated with future development, the base condition composite damage function would be used for the original four grid cells shown, whereas, a modified composite damage function would be used for the converted grid cell.

It is possible in a single computer run to uniformly flood proof as many land use categories as desired and to have a unique flood proofing level for each category.

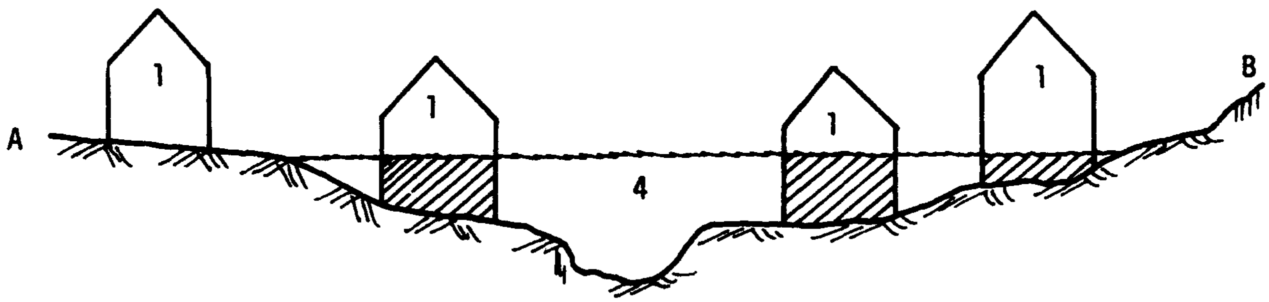
<u>Flood Proofing to a Specified Protection Level</u>. Flood proofing selected land uses to a specified protection level (within a given damage reach) requires the computation of the depth of flooding in each grid cell resulting from a flood event equivalent to the protection level specified. If a cell is inundated by that flood event, it is then flood proofed to an elevation corresponding to the depth of flooding. In general, flood proofing a damage reach to a particular frequency protection level would require some grid cells of a given land use category to be protected several feet, while others may need only the basements flood proofed or no protection at all (see Figure 4-7).

Construction of elevation-damage functions for this option is based on rating curve data (discharge versus stage or elevation) at the index locations. From a particular rating curve the elevation of the water surface at the index location which corresponds to the desired protection level is determined and input into the DAMCAL program. The corresponding protection level (elevation) is then computed for each grid cell using the reference flood, since changes in water surface elevation at the cell are consistent with changes in water surface elevation at the index location. (It should be remembered that damage reaches were defined based on essentially parallel water surface profiles). The flooded grid cells are subsequently flood proofed to protect against the specified event.

The computations are performed as follows: the reference flood elevation is subtracted from the target protection elevation at the index location



FLOODED AREA RESULTING FROM A SPECIFIED FREQUENCY FLOOD EVENT



EXAMPLE CROSS SECTION A-B

	Denotes depth of flood proofing required
1	Indicates low density housing
4	Indicates water body

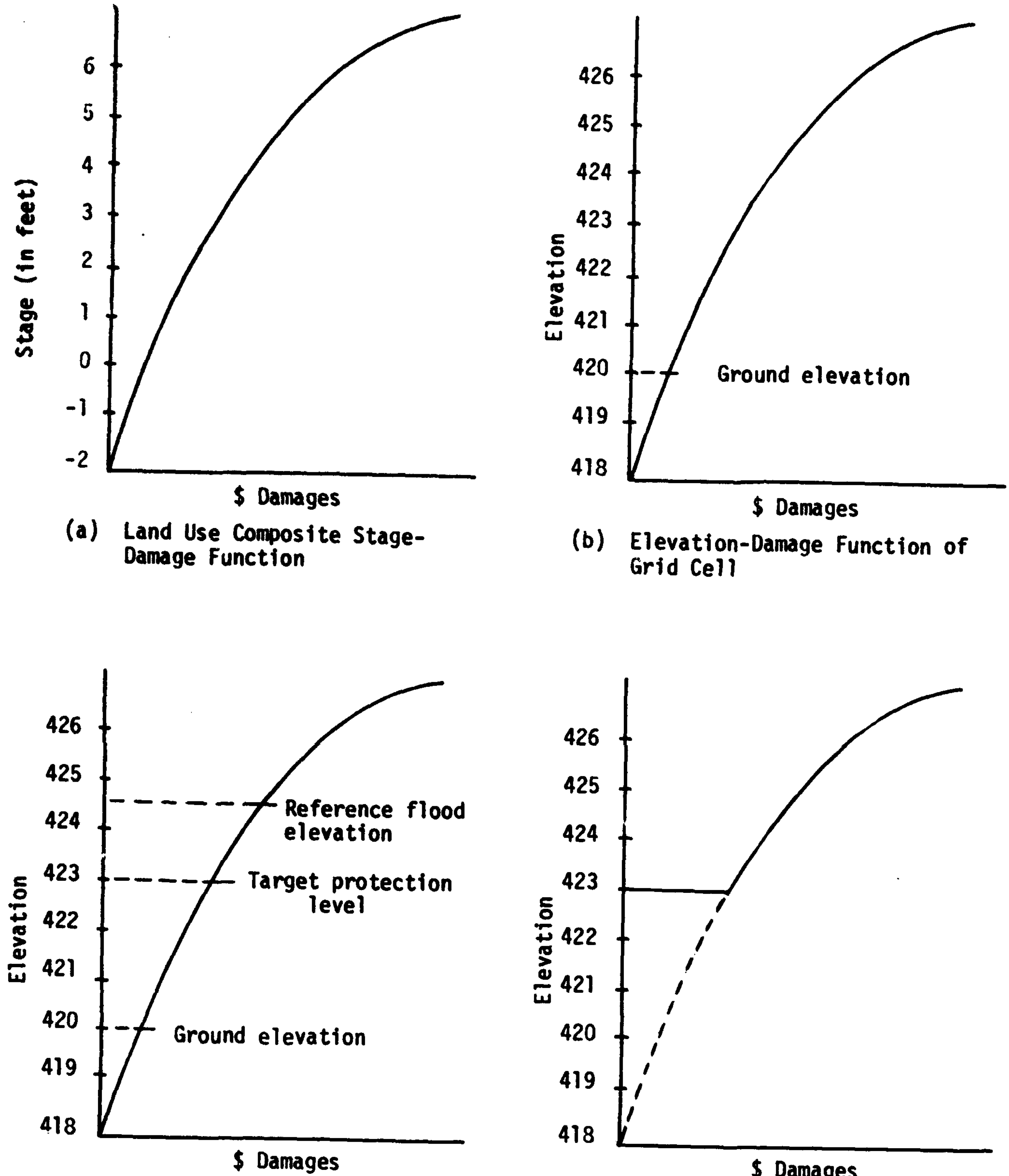
FIGURE 4-7

FLOOD PROOFING REQUIRED FOR A TARGET PROTECTION LEVEL

and the difference is added to the reference flood elevation of the grid cell. The computed elevation is the protection level water surface elevation. The amount of protection required for the grid cell is the protection elevation less the topographic (or ground) elevation. If the grid cell requires flood protection, the computer program truncates the elevation-damage curve at the protection level elevation. The process is repeated for each grid cell assigned to the damage reach.

Figure 4-8 illustrates the preceding computational procedure. The sample grid cell used has a ground elevation of 420.0 feet (see Figure 4-8b). The damage reach index location has a reference flood water surface elevation of 427.0 feet and a desired target protection level of 425.5 feet. The difference in water surface elevations at the index location is a minus 1.5 feet (425.5 - 427.0). The difference is added to the reference flood elevation of the grid cell to yield a corresponding target protection elevation (424.5 - 1.5 = 423.0 feet) for the cell (see Figure 4-8c). The elevation damage function is then truncated as shown in Figure 4-8d and aggregated to the index location in the usual manner. The option of flood proofing selected land use categories within a damage reach to various frequency flood events can be done for 1) existing conditions, 2) alternative land use conditions, and 3) alternative land use conditions considering the flood proofing of new development only.

Response to Flood Warning Dissemination. The temporary evacuation of facilities within a damage reach is a component of the implementation of a flood warning system. This type of option is difficult to evaluate, not because of theory, but because it requires the estimation of the effect of a flood warning system on the stage-damage functions (for each land use category) as temporary protection measures are implemented. To evaluate the option, the stage-damage functions which are input to the DAMCAL program are modified (based on a percentage of the existing damage associated with each stage) for each damageable land use category that is affected. The modification in the stage-damage functions should include damage reduction



(a) Land Use Composite Stage-Damage Function

(b) Elevation-Damage Function of Grid Cell

(c) Elevation-Damage Function with Reference Flood and Target Protection Level

(d) Truncated Elevation-Damage Function for Grid Cell

FIGURE 4-8

GRID CELL DAMAGE FUNCTIONS
(TARGET PROTECTION LEVEL SPECIFIED)

to both the contents and the structure (a different percent reduction could be applied to each).

Since it is difficult to accurately estimate the damages reduced, several runs are made for different percent reductions of the composite damage functions to compute the break point necessary for the option to be cost effective. The cost effective possibilities are then evaluated to determine whether or not the level of damage reduction can be reasonably achieved. The evaluation of this optional flood damage reduction measure is done by directly modifying the composite stage-damage functions of the grid cell damage potential to an appropraite index location. This permits the flood warning option to be evaluated by itself or in combination with any of the other nonstructural alternatives.

Permanent Evacuation of the Flood Plain. The evaluation of permanent evacuation of the flood plain requires the spatial definition of the flood area and removal of all designated land uses from that area. In this option the reference flood is used for defining the flood plain in the same manner as described in the computation of flood proofing to a target protection level and permanent evacuation of a flood plain is in the development of the damage functions. Instead of a truncated elevation-damage function (as shown in Figure 4-8d), a no-damage (or a specified damage) function is aggregated to the index location.

Figure 4-9 (a reproduction of Figure 4-8c) is used to illustrate several important aspects related to permanent evacuation of a flood plain area. If the flood plain elevation computed for the grid cell is 423.0 feet (Flood #1 of Figure 4-9) then the land use occupying the grid cell would be removed and a no-damage potential (or a specified damage potential for a grid cell exhibiting less damageable properties) would be aggregated to the index location. If though, Flood #2 (a water surface elevation of 419.0 feet) is used to compute the flooded area to be evacuated, then the grid cell is considered outside the flood plain of interest (grid cell ground elevation above the computed elevation for Flood #2). An inspection

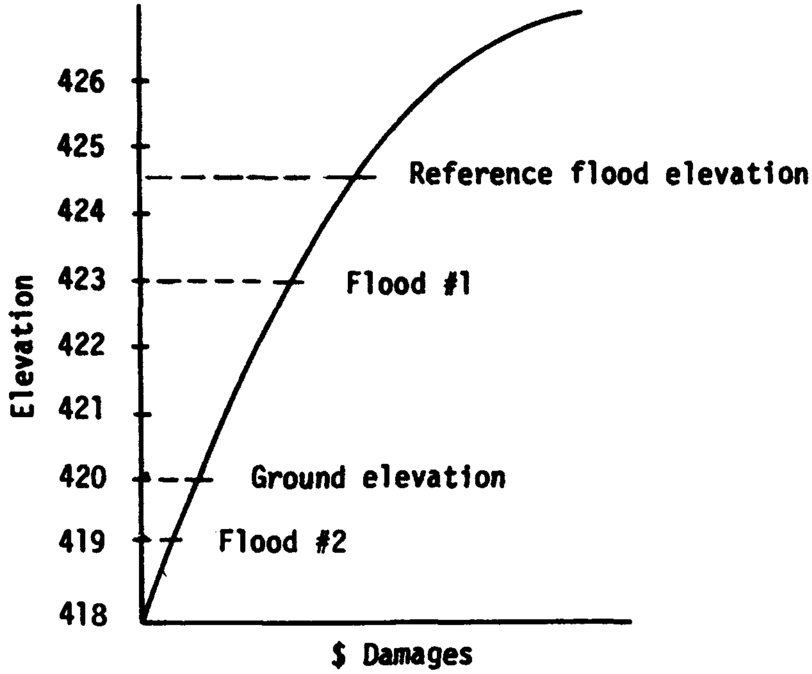


FIGURE 4-9

MULTIPLE FLOOD ELEVATIONS IN
CONJUNCTION WITH PERMANENT EVACUATION OF THE
FLOOD PLAIN

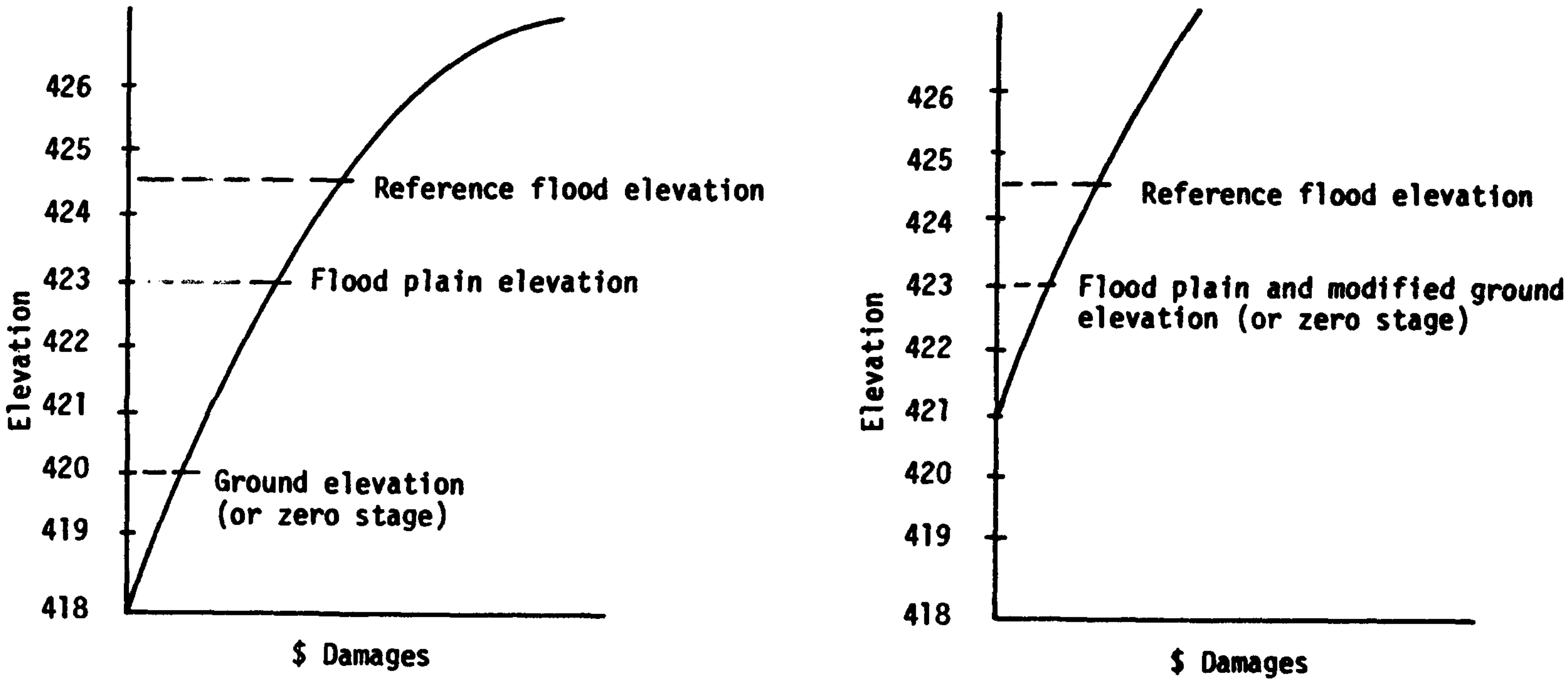
of Figure 4-9, in this case, indicates that the grid cell would still incur damages if Flood #2 occurred. The DAMCAL program has two options to permit analysis of the preceding flood plain conditions: 1) to permanently evacuate all grid cells for designated land use categories that are in the flood plain or 2) to evacuate all grid cells (of the designated land use categories) that incur damages due to the flood event of interest. If the latter option is used for the grid cell shown in Figure 4-9, then the cell land use would be removed in the case of Flood #2.

Flood Plain Regulation. Flood plain regulation is the zoning of the flood plain to restruct encroachment by major damageable land uses. In general, if a damageable land use is placed within the flood plain, then fill or some other means must be used to raise the first floor elevation above

the flood plain elevation. It is desirable, therefore, to evaluate the effect flood plain regulation has on potential flood damage reduction. The effectiveness of flood plain regulation in reducing potential damage is determined by constructing aggregated elevation-damage curves at each index location for the future land use pattern and the future land use pattern with the regulatory policy in effect. The aggregated elevation-damage curves are then used as the basis for comparison.

When a land use pattern is subjected to flood plain regulation, the analysis makes use of the reference flood to determine the flood plain of interest. The elevation of the regulatory flood (flood plain of interest) at the index location is determined by a method similar to that for flood proofing damage reaches to a specified protection level. If the computed regulatory flood event water surface elevation is higher than the topographic elevation of the grid cell, the elevation-damage function for the grid cell is elevated so that the ground elevation (or zero stage) is the same as the flood event water surface elevation. The corresponding change in the elevation-damage function is shown in Figure 4-10 (based on the grid cell example of Figure 4-8c). For a regulatory elevation of 423.0 feet, the elevation-damage function must be raised 3 feet to reflect the placement of ground elevation or zero stage at or above the regulated flood plain.

Even though a grid cell has its ground elevation (or zero stage) moved above a flood plain, it can still incur damages from the flood plain event. To accommodate this, the DAMCAL program has the capability to place the ground elevation or the zero-damage elevation at the flood plain elevation. Table 4-4 is an example taken from the Trail Creek Watershed (U.S. Army Corps of Engineers, 1975) comparing expected annual damages with and without flood plain regulation. The comparison is made for a 1990 future land use pattern with 1) no flood plain regulation, 2) flood plain regulation in which the ground elevation of new development must be constructed above the 100-year flood plain, and 3) flood plain regulation in which new development is required to position the zero-damage elevation above the 100-year flood plain.



(a) Elevation-Damage Function before Flood Plain Regulation

(b) Elevation-Damage Function after Flood Plain Regulation

FIGURE 4-10

GRID CELL ELEVATION-DAMAGE FUNCTION ADJUSTMENT
FOR FLOOD PLAIN REGULATION

(It should be noted from Table 4-4 that a significant reduction in potential damage results from possible flood plain regulation).

TABLE 4-4

COMPARISON OF EXPECTED ANNUAL DAMAGE
(in 1000's pf dollars)

Evaluation Condition	Damage Reach #1	Damage Reach #2	Damage Reach #3
Existing Land Use	1.5	2.5	12.0
1990 Land Use without Flood Plain Regulation	1033.3	350.0	32.7
1990 Land Use with Ground Elevation Regulation	19.3	63.8	23.8
1990 Land Use with Zero-Damage Regulation	9.2	6.7	3.0

The evaluation of flood plain regulation is not restricted to a 100-year flood plain, and it could be an alternative which is evaluated singularly or in combination with other flood proofing alternatives. For example, a combination of alternatives could place structures above the 75-year flood plain and uniformly flood proof to the 100-year flood event elevations.

Single Event Computation

DAMCAL has the capability to calculate damages which would occur for several specified frequency flood events while the program is aggregating damages to the index location. The capability is extremely useful because it eliminates errors which can occur when a user attempts to interpolate between elevation-damage values.

To illustrate the potential problem, Table 4-5 shows damages for a particular land use category at several elevations. If the 50-year flood event for the index location is 637.5 feet, a user might interpolate linearly between the elevations of 637 and 638 feet in estimating the damages at \$37,000. What is not known is whether the value of \$62,000 for an elevation of 638 feet represents a large number of grid cells with a tenth of a foot of flooding or if a small number of cells were experiencing greater depths of flooding. In the former case an elevation of 637.5 could result in a relatively insignificant increase in damages from that shown at an elevation of 637 feet (\$12,000). In the latter case the \$37,000 estimate could be a reasonable approximation of the damages due to a 50-year flood event.

TABLE 4-5

AGGREGATED ELEVATION-DAMAGE VALUES FOR A PARTICULAR LAND USE CATEGORY

Elevation	\$ Damages ($\times 10^3$)
640	120
639	65
638	62
637	12
636	10
635	0

In addition to the computation of damages for single events, the DAMCAL program creates a computer file which contains the grid cell location, the depth of flooding, the dollar damages, and the land use for each single event run. The information can be used to plot depth of flooding versus resulting damages or to partition damages by land use as an aid in determining the effect different flood plain management schemes would have on reducing the damage potential. The plotting of single event damages or flooded area displays can be accomplished using the RIA computer program (U.S. Army Corps of Engineers 1977).

Future Program Additions. Planned additions include 1) an automated damage function file transfer to the Expected Annual Flood Damage Computation (EAD) program (U.S. Army Corps of Engineers 1977) and 2) integration with the Structure Inventory of Damages (SID) computer program data file (Davis and Webb 1978). The former added capability will permit use of the comprehensive EAD program for detailed benefit studies and the latter added capability will permit the evaluation of unique damageable properties external to the grid cell data bank and the DAMCAL program without a double accounting of the damage potential. The need for additional features should be addressed to the Hydrologic Engineering Center.

Input Preparation

General Description. The following material describes the data (for the DAMCAL computer program) which are entered on each input card and the type of cards needed for the desired analysis to be performed.

The program is flexible to a degree in the data that can be input for analysis and in the detail of the output desired. Some of the input cards are optional and need not be provided unless required by the particular option which is specified.

Program Data Hierarchy. The general hierarchy of the major data types in this program is displayed in Table 4-6.

TABLE 4-6

PROGRAM DATA HIERARCHY

TITLE CARDS	
JOB CARDS	
- Type of Analysis	
- Size and Format of Grid Cell Data File	Apply to every job
- Data Variable Location	
- Nonstructural Analysis	
LAND USE CARDS	
- Value of Structure and Contents	
- Structure Density	Apply to each land use category analyzed
- Stage-Damage Relationships	
- Land Use Description	
DAMAGE REACH CARDS	
- Reference Flood Elevation	
- Aggregation Elevation Interval	Apply to each damage reach analyzed
- Single Event Elevation	
- Modification of Land Use Damages	

Data Card Description

Title Cards, T1, T2, T3. The title cards are required and they provide output display information that can readily identify the project and the particular job. The content of the title cards is optional, but it is suggested that they include a record of the project name, data notes, selected program options, and any unique features of the job. A numbering system that accounts for the job run for a particular project would prove useful. The information on the title cards is printed, in general, at the top of each page of the computer printout.

First Job Card, J1. This required card specifies the type of analysis to be performed (flood proofing, evacuation, single event, etc.), the printout

option and the file management option. The files generated by DAMCAL can be used as input to the ATODTA program (discussed in Section 5 of this report) and as input to the RIA computer program (U.S. Army Corps of Engineers, 1977) for flooded area displays.

Second Job Card, J2. This required card describes the computer file location of the data bank, the number of data variables, the dimensions of the data base, and whether or not the grid cell data bank is formatted.

Third Job Card, J3. This required card defines the sequence numbers of the data variables used in the analysis and the number of categories for particular data variables.

Fourth Job Card, J4. An optional card(s) used only when land use categories will have new development or all development raised above a specified flood level at the damage reach index location.

Fifth Job Card, J5. An optional card(s) used to specify land use categories that will be flood proofed.

Sixth Job Card, J6. An optional card(s) used to specify the depth of flood proofing for each of the land use categories listed on the J5 card(s).

Seventh Job Card, J7. An optional card(s) used to specify land use caregories that will be permanently evacuated.

Eighth Job Card, J8. An optional card used to identify the damage reach and land use within that damage reach for which trace printout is desired. (The printout is utilized primarily in determining coding and computational problems).

Format Card, FT. An optional card used to describe the format of a formatted data bank.

Single Flood Event Title Card, ST. An optional card containing the titles of the single flood events.

Composite Land Use Cards, LU, LT, DF, DS, DC, DO, DD. One set of composite land use cards is required for each land use category within the study area.

- Land Use Damage Card LU. A required card utilized at the start of each set of composite land use cards. The card, in general, contains information necessary to determine the composite stage damage relationship for a given land use category.

- Land Use Title Card, LT. A required card needed after each LU card. The card provides the land use title and the zero stage adjustment for the land use category described on the preceeding LU card.

- Depth of Flooding Card, DF. A required card(s) used to assign depth of flooding values to the composite stage-damage function of each land use category.

- Damage to Structure, Contents and Other Cards, DS, DC, DO. Optional card(s) utilized only if the DAMCAL program is used to construct the stage-damage function for a specified land use category. The cards contain the percent damage to structure (DS), to contents (DC), and to other (DO) associated with each depth value entered on the DF card(s). The damage to other category, DO card(s), is used either to capture indirect damages or to separate out unique content damages.

- Total Damage Card, DD. An optional card(s) used if the stage-damage relationship for a land use category has been previously computed (the DAMCAL program will not be used to construct the stage-damage function).

Damage Reach Cards, DR, DT, SE, LC. A set of damage reach cards is required for each damage reach in the analysis run.

- Damage Reach Card, DR. A required card needed to identify the damage reach code in the data bank and to give the corresponding reference flood elevation, the starting aggregation elevation, the aggregation interval and any policy, flood proofing or evacuation elevations that are necessary. The DR card is also used to create a new damage reach from the aggregation of the current damage reach and to modify land use densities and other input values.

- Damage Reach Title Card, DT. A required card needed after the DR card to describe the current damage reach.

- Single Flood Event Card, SE. An optional card necessary only for single flood event analysis. The card values represent the water surface elevations at the damage reach index location which correspond to the single flood events described on the ST card.

- Change to Land Use Damage Card, LC. An optional card(s) used to modify damage data for a specified land use(s) within the damage reach.

Ending Card, END. A required card that signals the end of the input data.

Output Display

The description of the output is accompanied by a sample printout, Exhibit 4-1. The output does not include all land use category damage functions or damage reach aggregated damage functions which would normally be printed. The numbers in parenthesis in the text refer to a specific line (or series of lines) that is numbered on the sample output.

Input Listing. A display of the input deck, pages 1 and 2 of Exhibit 4-1, is provided at user request (1).

Title. The information on the title cards is, in general, printed at the top of each output page (2).

Job Cards. The data on the job cards are first displayed in a card image format prior to a more descriptive definition of the variables. The variable and input values follow with a brief description of each variable.

- Analysis Information, J1 Card. An image of the required J1 card is displayed (3) and a description of the coded input values given (4).

- Data Bank Information, J2 Card. The required J2 card is shown in card image form (5) and the values that define the location, format, and size of the data bank are displayed and identified (6).

- Data Variable Information, J3 Card. The required J3 card is reproduced (7) and the values that define the data variables in the data bank are displayed and identified (8).

- Policy Data, J4, J5, J6, J7 Cards. The land use categories, whether existing or new development, subject to policy controls, flood proofing and permanent evacuation are shown (9).

- Trace Information, J8 Card. The damage reach and land use category to be displayed as trace output are indicated (10). The option generally would not be requested by the user.

Format Data. Since the DATA BANK is formatted, a format statement is provided in the output (11).

Composite Land Use Damage Data. The damage data relating to each land use category (as input) is printed out in tabular form as follows:

- Land Use Identifier. The land use category number is provided and is followed by the description or title (12).

- Damage Data. The values used to determine the damage function for each land use category are tabulated in the output. The column titles are related to the input variables as shown below:

  DEPTH OF WATER - DEPTH (I), DF Card (13).
  PERCENT DAMAGE STRUCTURE - DS(I), DS Card (14).
  PERCENT DAMAGE CONTENTS - DC(I), DC Card (15).
  PERCENT DAMAGE OTHER - DO(I),DO Card (16).
  AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS - Values for each grid cell of this land use category are calculated by the program (17).

- Land Use Information. The output reflects the information provided on the LU Card. The order of output follows:

  DENSITY OF LAND USE, UNITS PER GRID CELL - DENSITY, LU Card (18).
  BASE VALUE OF STRUCTURE - BASEVAL, LU Card (19)
  BASE VALUE OF THE CONTENTS - BASEVLU, LU Card (20).
  TOTAL DAMAGE OF OTHER WILL BE THE RESPECTIVE PERCENTAGE OF THE TOTAL - BASEIND, LU Card (21).
  VACANCY FACTOR (PERCENT DEVELOPED) - VACNCY, LU Card (22).

Damage Reach Index Location Summary. The data printed in the damage reach index location summary reflect the sequence of information input on the DR card(s). For each damage reach a value is given to each of the program variables listed below:

ID. NO., the identification number for the damage reach - JDR(I), DR Card (23).

REFERENCE FLOOD ELEVATION, the reference flood water surface elevation at the index location - REFFLD(I), DR Card (24).

POLICY FLOOD ELEVATION, the water surface elevation at the index location indicating the policy level - POLELV(I), DR Card (25).

FLOOD PROOFING ELEVATION, the water surface elevation at the index location indicating the level to be protected by floodproofing - PROELV(I), DR Card (26).

EVACUATION ELEVATION, the water surface elevation at the index location indicating the level of permanent evacuation - EVCELV(I), DR Card (27).

STARTING DAMAGE ELEVATION, the water surface elevation at the index location where the aggregated elevation damage functions begins - STRELV(I), DR Card (28).

DAMAGE ELEVATION INCREMENT, the increment between the water surface elevations for the calculation of damages at the index location - ELVINT(I), DR Card (29).

AGGREGATED DAMAGE REACH ID., the identifier of the new damage reach resulting from the aggregation of this damage reach - IAGGDR(I), DR Card (30).

MODIFY LAND USE DENSITY, the identifier to modify land use density and damage values - IMODFY(I), DR Card (31).

Single Events for Damage Reaches. When a single flood event analysis is performed, then the following information is printed out for each specified flood event:

- Title. The output reflects the information provided on the ST card (32).

- Water Surface Elevations. The water surface elevations at the index location indicating the flood levels of the flood events under analysis. The data is input on the SE card (33).

Trace Information as Specified on the J8 Card. As specified on the J8 card, grid cells designated as land use category 4 and within damage reach 1 are traced (34). In this particular case the trace provided information on two grid cells only. For each of these grid cells the program computes the adjusted elevation-damage function at the index location (35) and then accumulates the damages as each additional grid cell is analyzed (36).

Aggregated Damage Output. The following output is produced when the elevation-damage functions for all grid cells within a given damage reach are aggregated to the corresponding index location:

- Grid Cells Affected by Nonstructural Options. A listing is provided of those grid cells affected by the nonstructural options specified within the damage reaches analyzed (37).

- Minimum/Maximum Damage Levels. The grid cells that lie above or below the maximum and minimum water surface elevations specified at the index location for the computation of the aggregated elevation-damage function are identified (38). Grid cells with damages that start above the maximum damage elevation are not included in the aggregation process, whereas, grid cells with damages that start below the minimum damage elevation are truncated (only grid cell damages occurring between the minimum and maximum levels are included in the aggregation process).

- Damage Reach Identification. Each damage reach analyzed is identified by number and title (39).

- Aggregated Elevation Damage. A table of aggregated damages shows the dollar amount of damage (in thousands of dollars) for each land use category for various levels of water surface elevation at the index station location (40). Total damages for each water surface elevation increment are given in the far right column. Single event damages (as specified on the ST card) are also included in the table. (A similar table is provided for every damage reach analyzed).

- Damage-Land Use Table. The table relates the damage category value and land use code value to the appropriate land use category (41).

Sample Problems

Sample problems illustrating various types of calculations currently available utilizing the DAMCAL computer program are included in Exhibits 4-2, 4-3, 4-4, 4-5 and 4-6. The sample input and output will provide the user with an overall description of the data necessary for program execution. The sample problems will also provide a valid data set to verify program operations on other computer systems. The necessary data input categories and codes used from the Trail Creek data bank are incorporated in each of the problems. (It should be noted that the output displays for Exhibits 4-3, 4-4, 4-5 and 4-6 are incomplete. Stage-damage data are given for only one of the ten land use categories in the Trail Creek watershed).

REFERENCES

Davis, Darryl W. and Webb, R. Pat, May 1978, Flood Damage Assessments Using Spatial Data Management Techniques, The Hydrologic Engineering Center, Davis, California.

U.S. Army Corps of Engineers, September 1975, Phase I Oconee Basin Pilot Study - Trail Creek Test, The Hydrologic Engineering Center, Davis, California.

U.S. Army Corps of Engineers, June 1977, Expected Annual Flood Damage Computation, The Hydrologic Engineering Center, Davis, California.

U.S. Army Corps of Engineers, September 1978, Resource Information and Analysis, The Hydrologic Engineering Center, Davis, California.

U.S. Army Corps of Engineers, September 1978, Guide Manual for the Creation of Grid Cell Data Banks, The Hydrologic Engineering Center, Davis, California.

EXHIBIT 4-1

OUTPUT DISPLAY

DAMCAL-STAGE DAMAGE CALCULATION

LIST OF INPUT CARDS FOR THIS RUN ——— ——— ——— ——— ———→ (1) Input listing

```
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890

T1            OUTPUT DISPLAY
T2            DAMCAL-STAGE DAMAGE CALCULATION
T3            DECEMBER 1979
J1      2       4       2       1       0       1       0       5       0
J2      1       1      18      92     129       1
J3      5       2      11      10      10      14      13      31
J4      3       4       5       7       8
J5      3       4       5       7       8
J7      3       4       5       7       8
J8      1       4
FT(12F4.0,2F8.2,2F4.0,2F2.0)
ST2 YEAR 10 YEAR 20 YEAR 50 YEAR100 YEAR
LU      1       0       1       0       0       0    1.00       3
LT      1        NATURAL VEGETATION
DF   -.01       0      10
DD      0     .05     .05
LU      2       1       1       0       0     100    1.00       3
LT      2        DEVELOPED OPEN SPACE
DF   -.01       0      10
DS      0       0       0
DC      0       0       0
DD      0     100     100
LU      3       1     1.0   25000    7500       -     .60      16
LT      3        LOW DENSITY HOUSING
DF  -2.01      -2      -1       0       1       2       3       4       5       6
DF      7       8       9      10      11      12
DS      0       1       1      10      13      20      27      30      33      35
DS     36      40      41      41      45      45
DC      0       0       0       2      33      54      66      73      77      80
DC     81      81      81      81      81      81
DD      0       5       5       5       5       5       5       5       5       5
DD      5       5       5       5       5       5
LU      4       1       4   10000    -.30       -     .70      24
LT      4        MEDIUM DENSITY HOUSING
DF  -2.01      -2      -1       0       1       2       3       4       5       6
DF      7       8       9      10      11      12      13      14      15      16
DF     17      18      19      20
DS      0       1       2       4      11      18      24      26      29      31
DS     32      35      36      36      40      40      41      42      43      44
DS     45      45      45      45
DC      0       0       0       2      30      44      58      64      68      70
DC     71      71      73      74      74      74      74      74      74      74
DC     74      74      74      74      74
DD      0       5       5       5       5       5       5       5       5       4
DD      4       4       4       4       3       3       3       3       3       2
DD      2       2       2       2
LU      5       1      12   50000    -.30       -    1.00      24
```

```
LT     5          HIGH DENSITY HOUSING
DF -5.01      -5      -4      -3      -2      -1       0       1       2       3
DF     4       5       6       7       8       9      10      11      12      13
DF    14      15      16      17
DS     0       2       2       2       2       2       2       9      13      17
DS    20      21      23      24      26      33      37      41      43      45
DS   -46      48      50      50
DC     0       2       2       3       3       3       3      25      37      44
DC    46      47      48      48      48      52      62      67      71      74
DC    75      75      75      75
DD     0       5       5       5       5       5       5       5       5       5
DD     5       5       5       5       5       5       5       5       5       5
DD     5       5       5       5
LU     6       1       1     120       0       -    1.00      10
LT     6          AGRICULTURE
DF     0       1       2       3       4       5       6       7       8       9
DS     0    30.5      40      48    54.5    61.5    68.5    68.5    68.5    68.5
DC     0       0       0       0       0       0       0       0       0       0
DD     0       5       5       5       5       5       5       5       5       5
LU     7       1      .2  590000  885000  250000    1.00      20
LT     7          INDUSTRIAL
DF -2.01      -2      -1       0       1       2       3       4       5       6
DF     7       8       9      10      11      12      13      14      15      16
DS     0       1       1       7      12      16      24      27       2      31
DS    32      35      38      40      44      44      45      45      46      47
DC     0       0       0       5      28      37      43      49      55      59
DC    63      67      71      75      81      85      85      85      85      85
DD     0       0       0       5      15      20      22      30      45      50
DD    55      80      85      90      95      95      95      95      95      95
LU     9       1       4   50000    -.60       -     .80      15
LT     8          COMMERCIAL
DF -5.01      -5       0       1       2       3       4       5       6       7
DF     3       9      10      11      12
DS     0       1      10      14      20      27      30      33      35      36
DS    40      41      41      45      45
DC     0       0       2      33      54      66      73      77      80      81
DC    81      81      81      81      81
DD     0       5       5       5       5       5       5       5       5       5
DD     5       5       5       5       5
LU     9       1       1     120       0       -    1.00       8
LT     9          PASTURE
DF     0       1       2       3       4       5       6       7
DS     0       9      10      12      14      16      18      18
DC     0       0       0       0       0       0       0       0
DD     0       5       5       5       5       5       5       5
LU    10       1       1       0       0       0    1.00       2
LT    10          WATER BODIES
DF     0      10
DS     0       0
DC     0       0
DD     0       0
DR     1     634   627.1   627.1   624.0     610       1       0       0
DT DAMAGE REACH 1 - OCONEE TO CONFLUENCE
SE 616.7   623.5   624.0   625.6   627.1
DR     3     714   711.9   711.9   710.8     695       1       0       0
DT DAMAGE REACH 3 - LAST SECTION OF WEST FORK
SE 709.6   710.2   710.8   711.5   711.9
END
```

→ (1) Input listing (continued)

Exhibit 4-1

```
                      OUTPUT DISPLAY
                      DAMCAL-STAGE DAMAGE CALCULATION  ---------------> (2) Title
                      DECEMBER 1978


              J1 CARD
              -------
CC 1234567890123456789012345678901234567890123456789012345678901234567890
   J1   2    4    2    1    0    1    0    5    0          ---------------> (3) J1 card image

              ANALYSIS INFORMATION  ---------------------------------------> (4) Display of J1 card
              --------------------                                              values

              IPOL     =    2, SPECIFIED NEW DEVELOPMENT WILL HAVE THEIR GROUND FLOOR
                               PLACED ABOVE A POLICY LEVEL

              IPROF    =    4, SPECIFIED NEW DEVELOPMENT WILL BE FLOOD PROOFED TO A SPECIFIED LEVEL

              IEVAC    =    2, EVACUATE ALL NEW DEVELOPMENT WHICH HAS ITS GROUND LEVEL
                               IN THE RESTRICTED FLOOD PLAIN

              IEVCLU   =    1, EVACUATED CELLS WILL BE AGGREGATED INTO THIS LAND USE CATEGORY

              IPRNT    =    0, NORMAL PRINTOUT

              ITRACE   =    1, TRACE OUTPUT REQUESTED

              IAUTO    =    0, NO FILE CREATED FOR AUTDIA PROGRAM

              ITYPE    =    5, NUMBER OF SINGLE EVENT DAMAGES TO BE CALCULATED

              IAG      =    0, NO AGGREGATION OF SINGLE EVENT DAMAGES

              ISTRUC                       I
```

```
                    J2 CARD
                    -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J2     1       1       18        92       129       1
```
→ (5) J2 card image

```
DATA BANK INFORMATION
---------------------
```
→ (6) Display of J2 card values

```
NFILE    =     1, THE DATA BANK IS ON THIS COMPUTER UNIT
NFORM    =     1, THE DATA BANK IS FORMATTED
NDV      =    18, THE NUMBER OF DATA VARIABLES
IROW     =    92, THE NUMBER OF ROWS IN THE DATA BANK
ICOL     =   129, THE NUMBER OF COLUMNS IN THE DATA BANK
IMAGE    =     1, PRINTED IMAGE OF INPUT DECK
```

```
                    J3 CARD
                    -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J3     5       2       11        10        10        14        13        31
```
→ (7) J3 card image

```
DATA VARIABLE INFORMATION
-------------------------
```
→ (8) Display of J3 card values

```
IDAMRC   =     5, THE DATA VARIABLE THAT IS THE DAMAGE REACH CODE
NDDR     =     2, THE NUMBER OF DAMAGE REACHES IN THIS ANALYSIS
ILAND    =    11, THE DATA VARIABLE THAT IS THE LAND USE ANALYZED
IBASE    =    10, THE DATA VARIABLE CONSIDERED THE BASE CONDITION
NOLUC    =    10, THE NUMBER OF LAND USE CATEGORIES
ITOPO    =    14, THE DATA VARIABLE THAT IS TOPOGRAPHY
IREFD    =    13, THE DATA VARIABLE THAT IS THE REFERENCE FLOOD ELEVATION
IELV     =    31, THE NUMBER OF ELEVATION-DAMAGE POINTS TO BE CALCULATED
```

```
                              J4 CARD(S)           THE FOLLOWING LAND USE CATEGORIES
                              ==========           ARE SUBJECT TO POLICY CONTROLS
                                                   ==============================
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J4      3        4        5        7         8

                                                   THE FOLLOWING LAND USE CATEGORIES WITH NEW
                              J5 CARD(S)           DEVELOPMENT ARE SUBJECT TO FLOOD PROOFING
                              ==========           =========================================
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J5      3        4        5        7         8

                                                   THE FOLLOWING LAND USE CATEGORIES WITH
                              J7 CARD(S)           NEW DEVELOPMENT ARE SUBJECT TO EVACUATION
                              ==========           =========================================
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J7      3        4        5        7         8
```

(9) Display of policy data

```
                              J8 CARD
                              =======
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J8      1        4

                              TRACE INFORMATION
                              =================

                              NNDR    =     1, TRACE OUTPUT PROVIDED IN THIS DAMAGE REACH

                              NNLU    =     4, TRACE OUTPUT PROVIDED FOR THIS LAND USE CATEGORY
```

(10) Display of trace information

```
                              FORMAT CARD
                              ===========
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   FT(12F4.0,2F8.2,2F4.0,2F2.0)
```

(11) Display of format data

Exhibit 4-1
5 of 11

OUTPUT DISPLAY
DAMCAL-STAGE DAMAGE CALCULATION
DECEMBER 1978

LAND USE CATEGORY NO. 3

LOW DENSITY HOUSING —— (12) Land use identifier

(13) DEPTH OF WATER	(14) PERCENT DAMAGE STRUCTURE	(15) PERCENT DAMAGE CONTENTS	(16) PERCENT DAMAGE OTHER	(17) AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-2.01	0.	0.	0.	0.
-2.00	1.00	0.	5.00	.15
-1.00	1.00	0.	5.00	.15
0.	10.00	2.00	5.00	1.59
1.00	13.00	33.00	5.00	3.44
2.00	20.00	54.00	5.00	5.43
3.00	27.00	66.00	5.00	7.02
4.00	30.00	73.00	5.00	7.79
5.00	33.00	77.00	5.00	8.42
6.00	35.00	80.00	5.00	8.85
7.00	36.00	81.00	5.00	9.05
8.00	40.00	81.00	5.00	9.65
9.00	41.00	81.00	5.00	9.80
10.00	41.00	81.00	5.00	9.80
11.00	45.00	81.00	5.00	10.40
12.00	45.00	81.00	5.00	10.40

DENSITY OF THE LAND USE UNITS PER GRID CELL = 1.00 —— (18)

BASE VALUE OF THE STRUCTURE = 25000.00 —— (19)

BASE VALUE OF THE CONTENTS = 7500.00 —— (20)

BASE VALUE OF OTHER = -0. —— (21)

VACANCY FACTOR (PERCENT DEVELOPED) = 60.0 —— (22)

ONLY NEW DEVELOPMENT WITH THIS LAND USE WILL BE RAISED SO THE GROUND FLOOR IS ABOVE A SPECIFIED LEVEL

ONLY NEW DEVELOPMENT IN THIS LAND USE WILL BE FLOOD PROOFED TO A SPECIFIED PROTECTION LEVEL

ALL GRID CELLS WITH NEW DEVELOPMENT AND THIS LAND USE WHICH HAVE THEIR GROUND FLOOR
IN THE RESTRICTED FLOOD PLAIN WILL BE EVACUATED AND THE DAMAGES WILL BE AGGREGATED INTO LAND USE 1

OUTPUT DISPLAY
DAMCAL-STAGE DAMAGE CALCULATION
DECEMBER 1978

DAMAGE REACH INDEX LOCATION SUMMARY

(23) ID. NO.	(24) REFERENCE FLOOD ELEVATION	(25) POLICY FLOOD ELEVATION	(26) FLOOD PROOFING ELEVATION	(27) EVACUATION ELEVATION	(28) STARTING DAMAGE ELEVATION	(29) DAMAGE ELEVATION INCREMENT	(30) AGGREGATED DAMAGE RCH. ID.	(31) MODIFY LAND USE DENSITY
1.	634.0	627.1	627.1	624.0	610.0	1.00	0	0
3.	714.0	711.9	711.9	710.8	695.0	1.00	0	0

SINGLE EVENTS FOR DAMAGE REACHES

DAMAGE REACH NO.	2 YEAR EVENT	10 YEAR EVENT	20 YEAR EVENT	50 YEAR EVENT	100 YEAR EVENT
1.	616.7	623.5	624.0	625.6	627.1
3.	709.6	710.2	710.8	711.5	711.9

(32) Titles of flood events

(33) Water surface elevations at the index locations for the flood events

DAMAGE REACH 1 IS BEING TRACED FOR LAND USE 4 → (34) Trace printout as specified on J8 card

* INDICATES ELEVATION IS AT GRID CELL

ROW	COL	ARRAY INDEX	BASE L.U.	ALT. L.U.	*REF. FLOOD ELEV.	* POLICY ELEV.	*TOPO BEFORE POLICY	*TOPO AFTER POLICY	FLOOD PROOF ELEV.	* EVAC. ELEV.	DAMAGE FUNCT. STAGE	DAMAGE ELEV. (35)	DAMAGE (35)	ACCUM. DAMAGE (36)
80	7	16	2	4	620.00	613.10	600.00	613.10	627.10	610.00	-2.10	625.00	0.	0.
80	7	17	2	4	620.00	613.10	600.00	613.10	627.10	610.00	-1.10	626.00	0.	0.
80	7	18	2	4	620.00	613.10	600.00	613.10	627.10	610.00	-.10	627.00	0.	0.
80	7	19	2	4	620.00	613.10	600.00	613.10	627.10	610.00	.90	628.00	5.31	5.31
80	7	20	2	4	620.00	613.10	600.00	613.10	627.10	610.00	1.90	629.00	8.72	8.72
80	7	21	2	4	620.00	613.10	600.00	613.10	627.10	610.00	2.90	630.00	11.34	11.34
80	7	22	2	4	620.00	613.10	600.00	613.10	627.10	610.00	3.90	631.00	12.55	12.55
80	7	23	2	4	620.00	613.10	600.00	613.10	627.10	610.00	4.90	632.00	13.71	13.71
80	7	24	2	4	620.00	613.10	600.00	613.10	627.10	610.00	5.90	633.00	14.49	14.49
80	7	25	2	4	620.00	613.10	600.00	613.10	627.10	610.00	6.90	634.00	14.89	14.89
80	7	26	2	4	620.00	613.10	600.00	613.10	627.10	610.00	7.90	635.00	15.68	15.68
80	7	27	2	4	620.00	613.10	600.00	613.10	627.10	610.00	8.90	636.00	16.17	16.17
80	7	28	2	4	620.00	613.10	600.00	613.10	627.10	610.00	9.90	637.00	16.29	16.29
80	7	29	2	4	620.00	613.10	600.00	613.10	627.10	610.00	10.90	638.00	17.30	17.30
80	7	30	2	4	620.00	613.10	600.00	613.10	627.10	610.00	11.90	639.00	17.42	17.42
80	7	31	2	4	620.00	613.10	600.00	613.10	627.10	610.00	12.90	640.00	17.67	17.67
80	8	22	2	4	620.00	613.10	620.00	620.00	627.10	610.00	-3.00	631.00	0.	12.55
80	8	23	2	4	620.00	613.10	620.00	620.00	627.10	610.00	-2.00	632.00	.28	13.99
80	8	24	2	4	620.00	613.10	620.00	620.00	627.10	610.00	-1.00	633.00	.56	15.05
80	8	25	2	4	620.00	613.10	620.00	620.00	627.10	610.00	0.	634.00	2.69	17.58
80	8	26	2	4	620.00	613.10	620.00	620.00	627.10	610.00	1.00	635.00	5.60	21.28
80	8	27	2	4	620.00	613.10	620.00	620.00	627.10	610.00	2.00	636.00	9.07	25.24
80	8	28	2	4	620.00	613.10	620.00	620.00	627.10	610.00	3.00	637.00	11.59	27.88
80	8	29	2	4	620.00	613.10	620.00	620.00	627.10	610.00	4.00	638.00	12.66	29.96
80	8	30	2	4	620.00	613.10	620.00	620.00	627.10	610.00	5.00	639.00	13.83	31.25
80	8	31	2	4	620.00	613.10	620.00	620.00	627.10	610.00	6.00	640.00	14.56	32.23

DAMAGE REACH 1 HAS 9. CELLS THAT WERE RAISED TO COMPLY WITH POLICY CONTROLS
DAMAGE REACH 3 HAS 1. CELLS THAT WERE RAISED TO COMPLY WITH POLICY CONTROLS

(37) Grid cells affected by nonstructural options

DAMAGE REACH 1 HAS 16. CELLS THAT WERE FLOOD PROOFED TO SPECIFIED LEVELS
DAMAGE REACH 3 HAS 4. CELLS THAT WERE FLOOD PROOFED TO SPECIFIED LEVELS

DAMAGE REACH 3 HAS 12. CELLS WITH DAMAGES STARTING BELOW THE STARTING AGGREGATION ELEVATION

(38) Grid cells above or below minimum and maximum specified aggregating elevations

DAMAGE REACH 1 HAS 160. CELLS WITH DAMAGES STARTING ABOVE THE HIGHEST AGGREGATION ELEVTION
DAMAGE REACH 3 HAS 137. CELLS WITH DAMAGES STARTING ABOVE THE HIGHEST AGGREGATION ELEVTION

OUTPUT DISPLAY
DAMCAL-STAGE DAMAGE CALCULATION
DECEMBER 1978
DAMAGE REACH NO. 1

DAMAGE REACH 1 - OCONEE TO CONFLUENCE

(39) Damage reach identification and title

LAND USE CATEGORIES

(40) Table of aggregated damages

WATER SURFACE ELEVATION	1	2	3	4	5	6	7	8	9	10	TOTAL
610.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
611.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
612.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
613.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
614.0	.15	0.	0.	0.	0.	0.	0.	0.	0.	0.	.15
615.0	.15	0.	0.	0.	0.	0.	0.	0.	.07	0.	.22
616.0	.15	0.	0.	0.	0.	0.	0.	0.	.10	0.	.25
617.0	.20	0.	0.	0.	0.	0.	0.	0.	.12	0.	.32
618.0	.25	0.	0.	0.	0.	0.	0.	0.	.15	0.	.40
619.0	.25	0.	0.	0.	0.	0.	0.	0.	.18	0.	.43
620.0	.35	0.	0.	0.	0.	0.	0.	0.	.25	0.	.60
621.0	.40	0.	0.	0.	0.	0.	0.	0.	.27	0.	.67
622.0	.45	0.	0.	0.	0.	0.	0.	0.	.29	0.	.74
623.0	.45	0.	0.	0.	0.	0.	0.	0.	.31	0.	.76
624.0	.55	.30	0.	0.	0.	0.	0.	0.	.33	0.	1.18
625.0	.55	.30	0.	0.	0.	0.	0.	0.	.39	0.	1.24
626.0	.55	.30	0.	0.	0.	0.	0.	0.	.41	0.	1.26
627.0	.70	.30	0.	0.	0.	0.	0.	0.	.43	0.	1.43
627.1	.70	.40	0.	0.	0.	0.	0.	0.	.43	0.	1.53
628.0	.80	.40	0.	5.31	0.	0.	528.47	0.	.46	0.	535.44
629.0	.90	.40	0.	8.72	0.	0.	753.43	6.40	.49	0.	770.34
630.0	1.10	.40	0.	11.34	0.	0.	908.48	19.46	.52	0.	941.30
631.0	1.15	.40	0.	12.55	0.	0.	1054.19	32.51	.55	0.	1101.35
632.0	1.15	.40	0.	13.99	0.	0.	1139.71	45.57	.58	0.	1201.40

(continuation of preceding page)

633.0	1.25	.40	0.	15.05	0.	0.	1310.03	58.62	.64	0.	1385.99
634.0	1.80	1.00	0.	17.58	0.	0.	1405.55	71.68	.71	0.	1498.32
635.0	1.80	1.00	0.	21.28	0.	0.	1580.62	216.32	.89	0.	1821.92
636.0	1.80	1.00	0.	25.24	0.	0.	1693.58	335.36	.95	0.	2057.94
637.0	1.80	1.00	0.	27.88	0.	0.	1790.05	426.24	1.04	0.	2248.01
638.0	1.80	1.00	0.	29.96	0.	0.	1928.05	472.32	1.13	0.	2434.25
639.0	1.85	1.00	0.	31.25	0.	0.	1993.30	509.13	1.21	0.	2537.74
640.0	1.90	1.00	0.	32.23	0.	0.	2007.46	541.25	1.28	0.	2585.12
616.7 (2 YEAR)	.20	0.	0.	0.	0.	0.	0.	0.	.12	0.	.32
623.5 (10 YEAR)	.45	.10	0.	0.	0.	0.	0.	0.	.32	0.	.87
624.0 (20 YEAR)	.55	.30	0.	0.	0.	0.	0.	0.	.33	0.	1.18
625.6 (50 YEAR)	.55	.30	0.	0.	0.	0.	0.	0.	.40	0.	1.25
627.1 (100 YEAR)	.70	.40	0.	0.	0.	0.	0.	0.	.43	0.	1.53

(41) Table of damage-land use codes

DAMAGE CATEGORY	LAND USE CODE	LAND USE
1	1	NATURAL VEGETATION
2	2	DEVELOPED OPEN SPACE
3	3	LOW DENSITY HOUSING
4	4	MEDIUM DENSITY HOUSING
5	5	HIGH DENSITY HOUSING
6	6	AGRICULTURE
7	7	INDUSTRIAL
8	8	COMMERCIAL
9	9	PASTURE
10	10	WATER BODIES

EXHIBIT 4-2

SAMPLE PROBLEM

ECONOMIC EFFECT OF SINGLE FLOOD EVENTS
ON THE 1990 LAND USE PLAN

SAMPLE PROBLEM
ECONOMIC EFFECT OF SINGLE FLOOD EVENTS
ON THE 1990 LAND USE PLAN

Problem Statement

Determine the economic impact of five single flood events (2-year, 10-year, 20-year, 50-year and 100-year events) on the projected 1990 land use pattern, and request trace output for the medium density residential land use category in damage reach 1.

The format of the data file in the Trail Creek DATA BANK is (12F4.0, 2F8.2, 2F4.0, 2F2.0) and a listing of the pertinent items of the data base file is given in Table 1.

Description of Input Requirements

The title and particular job cards are required. The key input variables for this computation are ITYPE (J1.8), to identify the number of single flood events, NODR (J3.2), for indicating the number of damage reaches in the analysis, and ILAND (J3.4), to designate the land use pattern under investigation. It should be noted that the alphanumeric characters within the parenthesis following the variable name refer to particular cards and related card columns. As an example, the first two alphanumeric characters of (J1.8) indicate the J1-card and the character(s) following the decimal point indicates a particular field (or card column group). The J8 card is used to define the damage reach and land use category for trace output. The titles of the single flood events are input on the ST card, and the water surface elevations (WSE) at the index locations for each single flood event are recorded on the SE cards.

The completed coding sheets have been included in this sample problem.

Discussion of Results

The stage-damage functions for each land use category indicated in Table 1 are displayed, one per page. The input index location data (DR card values) for the two damage reaches analyzed are also shown (page 21 of 26) along with the single flood event water surface elevations (SE card values).

The trace information (page 22 of 26) indicates that only two grid cells identified with land use 4 and in damage reach 1 are included in the aggregation of damages for this reach with regard to the 1990 land use pattern. (It should be noted that the grid cells differ in topographic elevation by 20 feet). The accumulated damage (last column) for the second grid cell displayed reflects the combined aggregated damage for both grid cells (at the index location) at the elevations shown.

As shown by the printed information at the bottom of page 22, a total of 309 grid cells in the two damage reaches analyzed (damage reaches 1 and 3) fall outside the aggregated elevation damage function ranges specified on the DR cards. There are 12 cells with damages below the starting aggregation damage elevation and 297 cells with damages starting above the maximum elevation specified.

Aggregated elevation-damage values are tabulated for damage reaches 1 and 3 on pages 23, 24, 25, and 26 for each land use category within the 1990 land use pattern. (Note that the damages in land use category 4, pages 23 and 24, correspond to the accumulated damages displayed for the trace output, page 21).

TABLE 1

DATA BASE FILE DIRECTORY

FOR

THE TRAIL CREEK WATERSHED

Data Variable Code	Data Category Code	Identifying Title
1		GRID CELL ROW
	1	Row 1
	2-92	Rows 2-92
2		GRID CELL COLUMN
	1	Column 1
	2-129	Columns 2-129
3		WATERSHED
	1	Trail Creek
5		DAMAGE REACH
	1	Damage reach 1
	2-5	Damage reaches 2-5
10		EXISTING LAND USE
	1	Natural vegetation
	2	Developed open space
	3	Low density residential
	4	Medium density residential
	5	High density residential
	6	Agricultural
	7	Industrial
	8	Commercial
	9	Pasture
	10	Water bodies
11		1990 ALTERNATIVE LAND USE PATTERN
	1	Natural vegetation
	2	Developed open space
	3	Low density residential
	4	Medium density residential
	5	High density residential
	6	Agricultural
	7	Industrial
	8	Commercial
	9	Pasture
	10	Water bodies

TABLE 1 (continued)

DATA BASE FILE DIRECTORY

FOR

THE TRAIL CREEK WATERSHED

Data Variable Code	Data Category Code	Identifying Title
13		REFERENCE FLOOD ELEVATION Flood elevations to the nearest .1 foot are stored for each grid cell in the flood plain
14		TOPOGRAPHIC ELEVATION Land elevations to the nearest .1 foot are stored for each grid cell in the study area

GENERAL PURPOSE DATA FORM

(8 COLUMN FIELDS)

PROGRAM DAMCAL - EXHIBIT 4-2 DATE January 1979

REQUESTED BY D. Bundlach PREPARED BY CHECKED BY PAGE 1 of 4

	1	2	3	4	5	6	7	8	9	10
T1			SAMPLE PROBLEM						EXHIBIT 4-2	
T2			ECONOMIC EFFECT OF SINGLE FLOOD							
T3			EVENTS ON THE 1990 LAND USE PLAN.						JANUARY 1979	
J1	0	0.	0	0	0.	1	0	5	0	
J2	1	1	18	92	129.	0				
J3	5	2	11.	10	10	14	13.	31.		
JR	1.	4.								
FT(12F4.0, 2F8.2, 2F4.0, 2F2.0)										
ST 2 YEAR 10 YEAR 20 YEAR 50 YEAR 100 YEAR										
LU	1	0	1	0	0	0	1.00	3.		
LT	1		NATURAL VEGETATION							
DF	-.01	0	10							
DD	0.	.05	.05							
LU	2	1	1	0	0	100	1.00	3.		
LT	2.		DEVELOPED OPEN SPACE							
DF	-.01	0	10							
DS	0.	0.	0							
DC	0	0	0.							
DD	0	100	100							
LU	3.	1	1.0.	25000	7500.	-.	.60	16.		
LT	3.		LOW DENSITY HOUSING							
DF	-2.01	-2	-1	0	1	2	3.	4.	5	6
DF	7.	8.	9.	10	11.	12.				
DS	0	1	1	10	13.	20	27.	30.	33.	35
DS	36.	40	41	41.	45	45				
DC	0	0	0	2.	33.	54	66	73.	77.	80
DC	81.	81.	81.	81.	81.	81.				
DD	0	5.	5	5	5.	5.	5.	5.	5.	5
DD	5.	5.	5	5	5.	5.				
LU	4	1	4	10000	-.30	-	.70	.25		

GENERAL PURPOSE DATA FORM

(8 COLUMN FIELDS)

PROGRAM DAMCAL - EXHIBIT 4-2 DATE January 1979

REQUESTED BY D. Gundlach PREPARED BY CHECKED BY PAGE 2 OF 4

1	2	3	4	5	6	7	8	9	10
LT 4	MEDIUM DENSITY HOUSING								
DF -2.0	-2	-1	0	1	2	3	4	5	6
DF 7	8	9	10	11	12	13	14	15	16
DF 17	18	19	20						
DS 0	1	2	9	11	18	21	26	28	31
DS 32	35	36	36	40	40	41	42	43	44
DS 45	45	45	45						
DC 0	0	0	2	30	48	58	64	68	70
DC 71	71	73	74	74	74	74	74	74	74
DC 74	74	74	74						
DD 0	5	5	5	5	5	5	5	5	4
DD 4	4	4	4	3	3	3	3	3	2
DD 2	2	2	2						
LU 5	1	12	50000	-.30	-.	1.00	24		
LT 5	HIGH DENSITY HOUSING								
DF -5.0	-5	-4	-3	-2	-1	0	1	2	3
DF 4	5	6	7	8	9	10	11	12	13
DF 14	15	16	17						
DS 0	2	2	2	2	2	2	9	13	17
DS 20	21	23	24	26	33	37	41	43	45
DS 46	48	50	50						
DC 0	2	2	3	3	3	3	25	37	43
DC 46	47	48	48	48	52	62	67	71	74
DC 75	75	75	75						
DD 0	5	5	5	5	5	5	5	5	5
DD 5	5	5	5	5	5	5	5	5	5
DD 5	5	5	5						
LU 6	1	1	120	9	-.	1.00	19		
LT 6	AGRICULTURE								
DF 0	1	2	3	4	5	6	7	8	9

GENERAL PURPOSE DATA FORM

(8 COLUMN FIELDS)

PROGRAM DAMCAL - EXHIBIT 4-2 DATE January 1979

REQUESTED BY O. Gundlach PREPARED BY CHECKED BY PAGE 3 of 4

	1	2	3	4	5	6	7	8	9	10
DS	0.	30.5	40.	48.	54.5	61.5	68.5	68.5	68.5	68.5
DC	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DP	0.	.5	.5	.5	.5	.5	.5	.5	.5	.5
LU	7.	1.	.2	590000.	885000.	250000.	1.00	.20		
LT	7.	INDUSTRIAL								
DF	-2.01	-2.	-1.	0.	1.	2.	3.	4.	5.	6.
DF	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
DS	0.	1.	1.	2.	12.	18.	28.	37.	39.	41.
DS	32.	35.	38.	40.	44.	44.	45.	45.	46.	47.
DC	0.	0.	0.	.5	28.	37.	43.	49.	55.	59.
DC	63.	67.	71.	75.	81.	85.	85.	85.	85.	85.
DP	0.	0.	0.	.5	.15	.20	.22	.30	.45	.50
DP	.55	.80	.85	.90	.95	.95	.95	.95	.95	.95
LU	8.	1.	4.	50000.	-.60	-.	.80	.15		
LT	8.	COMMERCIAL								
DF	-5.01	-5.	0.	1.	2.	3.	4.	5.	6.	7.
DF	8.	9.	10.	11.	12.					
DS	0.	1.	10.	17.	20.	27.	30.	33.	35.	36.
DS	40.	41.	41.	45.	45.					
DC	0.	0.	2.	33.	59.	66.	73.	77.	80.	81.
DC	81.	81.	81.	81.	81.					
DP	0.	.5	.5	.5	.5	.5	.5	.5	.5	.5
DP	.5	.5	.5	.5	.5					
LU	9.	1.	1.	120.	0.	-.	1.00	.8		
LT	9.	PASTURE								
DF	0.	1.	2.	3.	4.	5.	6.	7.		
DS	0.	9.	10.	12.	14.	16.	18.	18.		
DC	0.	0.	0.	0.	0.	0.	0.	0.		
DP	0.	.5	.5	.5	.5	.5	.5	.5		
LU	10.	1.	1.	0.	0.	0.	1.00	.2		

Exhibit 4-2
7 of 26

GENERAL PURPOSE DATA FORM
(8 COLUMN FIELDS)

PROGRAM: DAMCAL - EXHIBIT 4-2 DATE: January 1979
REQUESTED BY: D. Gundlach PREPARED BY: CHECKED BY: PAGE: 4 OF 4

	1	2	3	4	5	6	7	8	9	10
LT	10		WATER BODIES							
DF	0	10								
DS	0	0								
DC	0	0								
DØ	0	0								
DR	1	639				610	1	0	0	
DT	DAMAGE REACH 1-OCONEE TO CONFLUENCE									
SE	616.7	623.5	624.0	625.6	627.1					
DR	3	714				695	1	0	0	
DT	DAMAGE REACH 3-LAST SECTION OF WEST FORK									
SE	708.6	710.2	710.8	711.5	711.9					
END										

```
SAMPLE PROBLEM                                   EXHIBIT 4-2
ECONOMIC EFFECT OF SINGLE FLOOD
EVENTS ON THE 1990 LAND USE PLAN                 JANUARY 1979


                    J1 CARD
                    -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J1     0     0     0     0     0     1     0     5     0
                    IPOL     =     0, THERE IS NO POLICY CONTROL IN THIS RUN

                    IPROF    =     0, THERE IS NO FLOOD PROOFING IN THIS RUN

                    IEVAC    =     0, THERE IS NO PERMANENT EVACUATION IN THIS RUN

                    IEVCLL   =     0, THERE IS NO PERMANENT EVACUATION IN THIS RUN

                    IPRNT    =     0, NORMAL PRINTOUT

                    ITRACE   =     1, TRACE OUTPUT REQUESTED

                    IAUTO    =     0, NO FILE CREATED FOR ATODTA PROGRAM

                    ITYPE    =     5, NUMBER OF SINGLE EVENT DAMAGES TO BE CALCULATED

                    IAG      =     0, NO AGGREGATION OF SINGLE EVENT DAMAGES


                    J2 CARD
                    -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J2     1     1    18    92   129     0

                    DATA BANK INFORMATION
                    ---------------------

                    NFILE    =     1, THE DATA BANK IS ON THIS COMPUTER UNIT

                    NFORM    =     1, THE DATA BANK IS FORMATTED

                    NDV      =    18, THE NUMBER OF DATA VARIABLES

                    IROW     =    92, THE NUMBER OF ROWS IN THE DATA BANK

                    ICOL     =   129, THE NUMBER OF COLUMNS IN THE DATA BANK

                    IMAGE    =     0, NO PRINTED IMAGE OF INPUT DECK
```

```
                         J3 CARD
                         -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
    J3      5       2       11      10      10      14      13      31

                         DATA VARIABLE INFORMATION
                         -------------------------

                         IDAMRC  =    5, THE DATA VARIABLE THAT IS THE DAMAGE REACH CODE

                         NDDR    =    2, THE NUMBER OF DAMAGE REACHES IN THIS ANALYSIS

                         ILAND   =   11, THE DATA VARIABLE THAT IS THE LAND USE ANALYZED

                         IBASE   =   10, THE DATA VARIABLE CONSIDERED THE BASE CONDITION

                         NOLUC   =   10, THE NUMBER OF LAND USE CATEGORIES

                         ITOPO   =   14, THE DATA VARIABLE THAT IS TOPOGRAPHY

                         IRFFD   =   13, THE DATA VARIABLE THAT IS THE REFERENCE FLOOD ELEVATION

                         IELV    =   31, THE NUMBER OF ELEVATION-DAMAGE POINTS TO BE CALCULATED


                         J8 CARD
                         -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
    J8      1       4

                         TRACE INFORMATION
                         -----------------

                         NNDR    =    1, TRACE OUTPUT PROVIDED IN THIS DAMAGE REACH

                         NNLU    =    4, TRACE OUTPUT PROVIDED FOR THIS LAND USE CATEGORY


                         FORMAT CARD
                         -----------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   /T(12F4.0,2F8.2,2F4.0,2F2.0)
```

SAMPLE PROBLEM
ECONOMIC EFFECT OF SINGLE FLOOD
EVENTS ON THE 1990 LAND USE PLAN

EXHIBIT 4-2
JANUARY 1979

LAND USE CATEGORY NO. 1

NATURAL VEGETATION

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-.01	0.	0.	0.	0.
0.	0.	0.	0.	.05
10.00	0.	0.	0.	.05

DENSITY OF THE LAND USE UNITS PER GRID CELL = 1.00

BASE VALUE OF THE STRUCTURE = 0.

BASE VALUE OF THE CONTENTS = 0.

BASE VALUE OF OTHER = 0.

VACANCY FACTOR (PERCENT DEVELOPED) =100.0

NOTE DAMAGES ARE INPUT DIRECTLY
IF DAMAGES ARE TO BE ADJUSTED FOR THIS LAND USE CATEGORY BY DAMAGE REACH
THEN DENSITY, VACANCY, AND BASE VALUES MUST BE INPUT

SAMPLE PROBLEM
ECONOMIC EFFECT OF SINGLE FLOOD
EVENTS ON THE 1990 LAND USE PLAN

EXHIBIT 4-2
JANUARY 1979

LAND USE CATEGORY NO. 2

DEVELOPED OPEN SPACE

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-.01	0.	0.	0.	0.
0.	0.	0.	100.00	.10
10.00	0.	0.	100.00	.10

DENSITY OF THE LAND USE UNITS PER GRID CELL = 1.00

BASE VALUE OF THE STRUCTURE = 0.

BASE VALUE OF THE CONTENTS = 0.

BASE VALUE OF OTHER = 100.00

VACANCY FACTOR (PERCENT DEVELOPED) =100.0

SAMPLE PROBLEM
ECONOMIC EFFECT OF SINGLE FLOOD
EVENTS ON THE 1990 LAND USE PLAN

EXHIBIT 4-2

JANUARY 1979

LAND USE CATEGORY NO. 3

LOW DENSITY HOUSING

DEPTH OF WATER	PERCENT DAMAGE STRUCTURES	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-2.01	0.	0.	0.	0.
-2.00	1.00	0.	5.00	.15
-1.00	1.00	0.	5.00	.15
0.	10.00	2.00	5.00	1.59
1.00	13.00	33.00	5.00	3.44
2.00	20.00	54.00	5.00	5.43
3.00	27.00	66.00	5.00	7.02
4.00	30.00	73.00	5.00	7.79
5.00	33.00	77.00	5.00	8.42
6.00	35.00	80.00	5.00	8.85
7.00	38.00	81.00	5.00	9.05
8.00	40.00	81.00	5.00	9.65
9.00	41.00	81.00	5.00	9.80
10.00	41.00	81.00	5.00	9.80
11.00	45.00	81.00	5.00	10.40
12.00	45.00	81.00	5.00	10.40

DENSITY OF THE LAND USE UNITS PER GRID CELL = 1.00

BASE VALUE OF THE STRUCTURE = 25000.00

BASE VALUE OF THE CONTENTS = 7500.00

BASE VALUE OF OTHER = -0.

VACANCY FACTOR (PERCENT DEVELOPED) = 60.0

LAND USE CATEGORY NO. 4

MEDIUM DENSITY HOUSING

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-2.01	0.	0.	0.	0.
-2.00	1.00	0.	5.00	.28
-1.00	2.00	0.	5.00	.56
0.	9.00	2.00	5.00	2.69
1.00	11.00	30.00	5.00	5.60
2.00	18.00	48.00	5.00	9.07
3.00	24.00	58.00	5.00	11.59
4.00	26.00	64.00	5.00	12.66
5.00	29.00	68.00	5.00	13.83
6.00	31.00	70.00	4.00	14.56
7.00	32.00	71.00	4.00	14.92
8.00	35.00	71.00	4.00	15.76
9.00	36.00	73.00	4.00	16.21
10.00	36.00	74.00	4.00	16.30
11.00	40.00	74.00	3.00	17.42
12.00	40.00	74.00	3.00	17.42
13.00	41.00	74.00	3.00	17.70
14.00	42.00	74.00	3.00	17.98
15.00	43.00	74.00	3.00	18.26
16.00	44.00	74.00	2.00	18.54
17.00	45.00	74.00	2.00	18.82
18.00	45.00	74.00	2.00	18.82
19.00	45.00	74.00	2.00	18.82
20.00	45.00	74.00	2.00	18.82

DENSITY OF THE LAND USE UNITS PER GRID CELL = 4.00

BASE VALUE OF THE STRUCTURE = 10000.00

BASE VALUE OF THE CONTENTS (30.00 PERCENT OF THE STRUCTURE VALUE) = 3000.00

BASE VALUE OF OTHER = -0.

VACANCY FACTOR (PERCENT DEVELOPED) = 70.0

LAND USE CATEGORY NO. 5

HIGH DENSITY HOUSING

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-5.01	0.	0.	0.	0.
-5.00	2.00	2.00	5.00	15.60
-4.00	2.00	2.00	5.00	15.60
-3.00	2.00	3.00	5.00	17.40
-2.00	2.00	3.00	5.00	17.40
-1.00	2.00	3.00	5.00	17.40
0.	2.00	3.00	5.00	17.40
1.00	9.00	25.00	5.00	99.00
2.00	13.00	37.00	5.00	144.60
3.00	17.00	44.00	5.00	181.20
4.00	20.00	46.00	5.00	202.80
5.00	21.00	47.00	5.00	210.60
6.00	23.00	48.00	5.00	224.40
7.00	24.00	48.00	5.00	230.40
8.00	26.00	48.00	5.00	242.40
9.00	33.00	52.00	5.00	291.60
10.00	37.00	62.00	5.00	333.60
11.00	41.00	67.00	5.00	366.60
12.00	43.00	71.00	5.00	385.80
13.00	45.00	74.00	5.00	403.20
14.00	46.00	75.00	5.00	411.00
15.00	48.00	75.00	5.00	423.00
16.00	50.00	75.00	5.00	435.00
17.00	50.00	75.00	5.00	435.00

DENSITY OF THE LAND USE UNITS PER GRID CELL =12.00

BASE VALUE OF THE STRUCTURE = 50000.00

BASE VALUE OF THE CONTENTS (30.00 PERCENT OF THE STRUCTURE VALUE) = 15000.00

BASE VALUE OF OTHER = =0.

VACANCY FACTOR (PERCENT DEVELOPED) =100.0

SAMPLE PROBLEM
ECONOMIC EFFECT OF SINGLE FLOOD
EVENTS ON THE 1990 LAND USE PLAN

LAND USE CATEGORY NO. 6

AGRICULTURE

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
0.	0.	0.	0.	0.
1.00	30.50	0.	5.00	.04
2.00	40.00	0.	5.00	.05
3.00	48.00	0.	5.00	.06
4.00	54.50	0.	5.00	.07
5.00	61.50	0.	5.00	.07
6.00	68.50	0.	5.00	.08
7.00	68.50	0.	5.00	.08
8.00	68.50	0.	5.00	.08
9.00	68.50	0.	5.00	.08

DENSITY OF THE LAND USE UNITS PER GRID CELL = 1.00

BASE VALUE OF THE STRUCTURE = 120.00

BASE VALUE OF THE CONTENTS = 0.

BASE VALUE OF OTHER = -0.

VACANCY FACTOR (PERCENT DEVELOPED) =100.0

SAMPLE PROBLEM
ECONOMIC EFFECT OF SINGLE FLOOD
EVENTS ON THE 1990 LAND USE PLAN

EXHIBIT 4-2
JANUARY 1979

LAND USE CATEGORY NO. 7

INDUSTRIAL

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-2.01	0.	0.	0.	0.
-2.00	1.00	0.	0.	1.18
-1.00	1.00	0.	0.	1.18
0.	7.00	5.00	5.00	19.61
1.00	12.00	28.00	15.00	71.22
2.00	18.00	37.00	20.00	96.73
3.00	24.00	43.00	22.00	115.43
4.00	27.00	49.00	30.00	133.59
5.00	29.00	55.00	45.00	154.07
6.00	31.00	59.00	50.00	166.01
7.00	32.00	63.00	55.00	176.77
8.00	35.00	67.00	80.00	199.89
9.00	38.00	71.00	85.00	213.01
10.00	40.00	75.00	90.00	224.95
11.00	44.00	81.00	95.00	242.79
12.00	44.00	85.00	95.00	249.87
13.00	45.00	85.00	95.00	251.05
14.00	45.00	85.00	95.00	251.05
15.00	46.00	85.00	95.00	252.23
16.00	47.00	85.00	95.00	253.41

DENSITY OF THE LAND USE UNITS PER GRID CELL = .20

BASE VALUE OF THE STRUCTURE =590000.00

BASE VALUE OF THE CONTENTS =885000.00

BASE VALUE OF OTHER =250000.00

VACANCY FACTOR (PERCENT DEVELOPED) =100.0

SAMPLE PROBLEM
ECONOMIC EFFECT OF SINGLE FLOOD
EVENTS ON THE 1990 LAND USE PLAN

EXHIBIT 4-2

JANUARY 1979

LAND USE CATEGORY NO. 8

COMMERCIAL

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-5.01	0.	0.	0.	0.
-5.00	1.00	0.	5.00	1.60
0.	10.00	2.00	5.00	17.92
1.00	14.00	33.00	5.00	54.08
2.00	20.00	54.00	5.00	83.84
3.00	27.00	66.00	5.00	106.56
4.00	30.00	73.00	5.00	118.08
5.00	33.00	77.00	5.00	126.72
6.00	35.00	80.00	5.00	132.80
7.00	36.00	81.00	5.00	135.36
8.00	40.00	81.00	5.00	141.76
9.00	41.00	81.00	5.00	143.36
10.00	41.00	81.00	5.00	143.36
11.00	45.00	81.00	5.00	149.76
12.00	45.00	81.00	5.00	149.76

DENSITY OF THE LAND USE UNITS PER GRID CELL = 4.00

BASE VALUE OF THE STRUCTURE = 50000.00

BASE VALUE OF THE CONTENTS (60.00 PERCENT OF THE STRUCTURE VALUE) = 30000.00

BASE VALUE OF OTHER = -0.

VACANCY FACTOR (PERCENT DEVELOPED) = 80.0

SAMPLE PROBLEM
ECONOMIC EFFECT OF SINGLE FLOOD
EVENTS ON THE 1990 LAND USE PLAN

EXHIBIT 4-2
JANUARY 1979

LAND USE CATEGORY NO. 9

PASTURE

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
0.	0.	0.	0.	0.
1.00	9.00	0.	5.00	.01
2.00	10.00	0.	5.00	.01
3.00	12.00	0.	5.00	.01
4.00	14.00	0.	5.00	.02
5.00	16.00	0.	5.00	.02
6.00	18.00	0.	5.00	.02
7.00	18.00	0.	5.00	.02

DENSITY OF THE LAND USE UNITS PER GRID CELL = 1.00

BASE VALUE OF THE STRUCTURE = 120.00

BASE VALUE OF THE CONTENTS = 0.

BASE VALUE OF OTHER = -0.

VACANCY FACTOR (PERCENT DEVELOPED) =100.0

SAMPLE PROBLEM
ECONOMIC EFFECT OF SINGLE FLOOD
EVENTS ON THE 1990 LAND USE PLAN

LAND USE CATEGORY NO. 10

WATER BODIES

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
0.	0.	0.	0.	0.
10.00	0.	0.	0.	0.

DENSITY OF THE LAND USE UNITS PER GRID CELL = 1.00

BASE VALUE OF THE STRUCTURE = 0.

BASE VALUE OF THE CONTENTS = 0.

BASE VALUE OF OTHER = 0.

VACANCY FACTOR (PERCENT DEVELOPED) =100.0

SAMPLE PROBLEM
ECONOMIC EFFECT OF SINGLE FLOOD
EVENTS ON THE 1990 LAND USE PLAN

EXHIBIT 4-2
JANUARY 1979

DAMAGE REACH INDEX LOCATION SUMMARY

ID. NO.	REFERENCE FLOOD ELEVATION	POLICY FLOOD ELEVATION	FLOOD PROOFING ELEVATION	EVACUATION ELEVATION	STARTING DAMAGE ELEVATION	DAMAGE ELEVATION INCREMENT	AGGREGATED DAMAGE RCH. ID.	MODIFY LAND USE DENSITY
1.	634.0	0.	0.	0.	610.0	1.00	0	0
3.	714.0	0.	0.	0.	695.0	1.00	0	0

SINGLE EVENTS FOR DAMAGE REACHES

DAMAGE REACH NO.	2 YEAR EVENT	10 YEAR EVENT	20 YEAR EVENT	50 YEAR EVENT	100 YEAR EVENT
1.	618.7	623.5	624.0	625.6	627.1
3.	708.6	710.2	710.8	711.5	711.9

DAMAGE REACH 1 IS BEING TRACED FOR LAND USE 4

* INDICATES ELEVATION IS AT GRID CELL

ROW	COL	ARRAY INDEX	BASE L.U.	ALT. L.U.	*REF. FLOOD ELEV.	* POLICY ELEV.	*TOPO BEFORE POLICY	*TOPO AFTER POLICY	FLOOD PROOF ELEV.	* EVAC. ELEV.	DAMAGE FUNCT. STAGE	DAMAGE ELEV.	DAMAGE	ACCUM. DAMAGE
80	7	2	2	4	620.00	0.	600.00	600.00	0.	0.	-3.00	611.00	0.	0.
80	7	3	2	4	620.00	0.	600.00	600.00	0.	0.	-2.00	612.00	.28	.28
80	7	4	2	4	620.00	0.	600.00	600.00	0.	0.	-1.00	613.00	.56	.56
80	7	5	2	4	620.00	0.	600.00	600.00	0.	0.	0.	614.00	2.69	2.69
80	7	6	2	4	620.00	0.	600.00	600.00	0.	0.	1.00	615.00	5.60	5.60
80	7	7	2	4	620.00	0.	600.00	600.00	0.	0.	2.00	616.00	9.07	9.07
80	7	8	2	4	620.00	0.	600.00	600.00	0.	0.	3.00	617.00	11.59	11.59
80	7	9	2	4	620.00	0.	600.00	600.00	0.	0.	4.00	618.00	12.66	12.66
80	7	10	2	4	620.00	0.	600.00	600.00	0.	0.	5.00	619.00	13.83	13.83
80	7	11	2	4	620.00	0.	600.00	600.00	0.	0.	6.00	620.00	14.56	14.56
80	7	12	2	4	620.00	0.	600.00	600.00	0.	0.	7.00	621.00	14.92	14.92
80	7	13	2	4	620.00	0.	600.00	600.00	0.	0.	8.00	622.00	15.76	15.76
80	7	14	2	4	620.00	0.	600.00	600.00	0.	0.	9.00	623.00	16.21	16.21
80	7	15	2	4	620.00	0.	600.00	600.00	0.	0.	10.00	624.00	16.30	16.30
80	7	16	2	4	620.00	0.	600.00	600.00	0.	0.	11.00	625.00	17.42	17.42
80	7	17	2	4	620.00	0.	600.00	600.00	0.	0.	12.00	626.00	17.42	17.42
80	7	18	2	4	620.00	0.	600.00	600.00	0.	0.	13.00	627.00	17.70	17.70
80	7	19	2	4	620.00	0.	600.00	600.00	0.	0.	14.00	628.00	17.98	17.98
80	7	20	2	4	620.00	0.	600.00	600.00	0.	0.	15.00	629.00	18.26	18.26
80	7	21	2	4	620.00	0.	600.00	600.00	0.	0.	16.00	630.00	18.54	18.54
80	7	22	2	4	620.00	0.	600.00	600.00	0.	0.	17.00	631.00	18.82	18.82
80	7	23	2	4	620.00	0.	600.00	600.00	0.	0.	18.00	632.00	18.82	18.82
80	7	24	2	4	620.00	0.	600.00	600.00	0.	0.	19.00	633.00	18.82	18.82
80	7	25	2	4	620.00	0.	600.00	600.00	0.	0.	20.00	634.00	18.82	18.82
80	7	26	2	4	620.00	0.	600.00	600.00	0.	0.	21.00	635.00	18.82	18.82
80	7	27	2	4	620.00	0.	600.00	600.00	0.	0.	22.00	636.00	18.82	18.82
80	7	28	2	4	620.00	0.	600.00	600.00	0.	0.	23.00	637.00	18.82	18.82
80	7	29	2	4	620.00	0.	600.00	600.00	0.	0.	24.00	638.00	18.82	18.82
80	7	30	2	4	620.00	0.	600.00	600.00	0.	0.	25.00	639.00	18.82	18.82
80	7	31	2	4	620.00	0.	600.00	600.00	0.	0.	26.00	640.00	18.82	18.82
80	8	22	2	4	620.00	0.	620.00	620.00	0.	0.	-3.00	631.00	0.	18.82
80	8	23	2	4	620.00	0.	620.00	620.00	0.	0.	-2.00	632.00	.28	19.10
80	8	24	2	4	620.00	0.	620.00	620.00	0.	0.	-1.00	633.00	.56	19.38
80	8	25	2	4	620.00	0.	620.00	620.00	0.	0.	0.	634.00	2.69	21.50
80	8	26	2	4	620.00	0.	620.00	620.00	0.	0.	1.00	635.00	5.60	24.42
80	8	27	2	4	620.00	0.	620.00	620.00	0.	0.	2.00	636.00	9.07	27.89
80	8	28	2	4	620.00	0.	620.00	620.00	0.	0.	3.00	637.00	11.59	30.41
80	8	29	2	4	620.00	0.	620.00	620.00	0.	0.	4.00	638.00	12.66	31.47
80	8	30	2	4	620.00	0.	620.00	620.00	0.	0.	5.00	639.00	13.83	32.65
80	8	31	2	4	620.00	0.	620.00	620.00	0.	0.	6.00	640.00	14.56	33.38

DAMAGE REACH 3 HAS 12. CELLS WITH DAMAGES STARTING BELOW THE STARTING AGGREGATION ELEVATION

DAMAGE REACH 1 HAS 160. CELLS WITH DAMAGES STARTING ABOVE THE HIGHEST AGGREGATION ELEVTION
DAMAGE REACH 3 HAS 137. CELLS WITH DAMAGES STARTING ABOVE THE HIGHEST AGGREGATION ELEVTION

SAMPLE PROBLEM
ECONOMIC EFFECT OF SINGLE FLOOD
EVENTS ON THE 1990 LAND USE PLAN
DAMAGE REACH NO. 1

EXHIBIT 4-2

JANUARY 1979

DAMAGE REACH 1-OCONEE TO CONFLUENCE

LAND USE CATEGORIES

WATER SURFACE ELEVATION	1	2	3	4	5	6	7	8	9	10	TOTAL
610.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
611.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
612.0	0.	0.	0.	.28	0.	0.	8.26	0.	0.	0.	8.54
613.0	0.	0.	0.	.56	0.	0.	8.26	0.	0.	0.	8.82
614.0	.15	0.	0.	2.69	0.	0.	137.27	0.	0.	0.	140.11
615.0	.15	0.	0.	5.60	0.	0.	498.54	0.	.07	0.	504.36
616.0	.15	0.	0.	9.07	0.	0.	678.29	0.	.10	0.	687.61
617.0	.20	0.	0.	11.59	0.	0.	822.09	0.	.12	0.	834.01
618.0	.25	0.	0.	12.66	0.	0.	990.67	0.	.15	0.	1003.92
619.0	.25	0.	0.	13.85	0.	0.	1167.57	0.	.18	0.	1181.83
620.0	.35	0.	0.	14.56	0.	0.	1271.89	0.	.25	0.	1287.05
621.0	.40	0.	0.	14.92	0.	0.	1365.53	0.	.27	0.	1381.12
622.0	.45	0.	0.	15.76	0.	0.	1547.16	0.	.29	0.	1563.66
623.0	.45	0.	0.	16.21	0.	0.	1653.50	0.	.31	0.	1670.47
624.0	.55	.30	0.	16.50	0.	0.	1748.19	0.	.33	0.	1765.87
625.0	.55	.30	0.	17.42	0.	0.	1892.48	0.	.39	0.	1911.14
626.0	.55	.30	0.	17.42	0.	0.	1958.16	0.	.41	0.	1976.84
627.0	.70	.30	0.	17.71	0.	0.	1978.72	0.	.43	0.	1997.84
628.0	.80	.40	0.	17.98	0.	0.	1994.79	0.	.46	0.	2014.43
629.0	.90	.40	0.	18.26	0.	0.	2013.36	6.40	.49	0.	2039.80
630.0	1.10	.40	0.	18.54	0.	0.	2024.57	19.46	.52	0.	2064.58
631.0	1.15	.40	0.	18.82	0.	0.	2024.92	32.51	.55	0.	2078.35
632.0	1.15	.40	0.	19.10	0.	0.	2025.75	45.57	.58	0.	2092.54

633.0	1,25	.40	0.	19,38	0.	0.	2026.93	58,62	.64	0.	2107,22
634.0	1.80	1,00	0.	21.50	0.	0.	2027,28	71,68	.71	0.	2123,97
635.0	1.80	1,00	0.	24,42	0.	0.	2027,28	216,32	.89	0.	2271,71
636.0	1.80	1,00	0.	27,69	0.	0.	2027,28	335,36	.95	0.	2394,28
637.0	1.80	1,00	0.	30,41	0.	0.	2027,28	426,24	1,04	0.	2487,77
638.0	1.80	1,00	0.	31,47	0.	0.	2027,28	472,32	1,13	0.	2535,00
639.0	1.85	1,00	0.	32,65	0.	0.	2027,28	509,13	1,21	0.	2573,12
640.0	1.90	1,00	0.	33,38	0.	0.	2027,28	541,25	1,28	0.	2606,10
616.7 (2 YEAR)	.20	0.	0.	10,84	0.	0.	777,29	0.	.12	0.	788,45
623.5 (10 YEAR)	.45	.10	0.	16,25	0.	0.	1701,02	0.	.32	0.	1718,14
624.0 (20 YEAR)	.55	.30	0.	16,30	0.	0.	1748,19	0.	.33	0.	1765,67
625.6 (50 YEAR)	.55	.30	0.	17.42	0.	0.	1933,09	0.	.40	0.	1951,76
627.1 (100 YEAR)	.70	.40	0.	17,72	0.	0.	1979,91	0.	.43	0.	1999,17

DAMAGE CATEGORY	LAND USE CODE	LAND USE
1	1	NATURAL VEGETATION
2	2	DEVELOPED OPEN SPACE
3	3	LOW DENSITY HOUSING
4	4	MEDIUM DENSITY HOUSING
5	5	HIGH DENSITY HOUSING
6	6	AGRICULTURE
7	7	INDUSTRIAL
8	8	COMMERCIAL
9	9	PASTURE
10	10	WATER BODIES

SAMPLE PROBLEM
ECONOMIC EFFECT OF SINGLE FLOOD
EVENTS ON THE 1990 LAND USE PLAN
DAMAGE REACH NO. 3

EXHIBIT 4-2

JANUARY 1979

DAMAGE REACH 3-LAST SECTION OF WEST FORK

LAND USE CATEGORIES

WATER SURFACE ELEVATION	1	2	3	4	5	6	7	8	9	10	TOTAL
695.0	.60	0.	0.	0.	0.	0.	0.	0.	0.	0.	.60
696.0	.70	0.	0.	0.	0.	0.	0.	0.	0.	0.	.70
697.0	.75	0.	0.	0.	0.	0.	0.	0.	0.	0.	.75
698.0	.75	0.	0.	0.	0.	0.	0.	0.	0.	0.	.75
699.0	.80	0.	0.	0.	0.	0.	0.	0.	0.	0.	.80
700.0	.85	0.	0.	0.	0.	0.	0.	0.	0.	0.	.85
701.0	.90	0.	0.	0.	0.	0.	0.	0.	0.	0.	.90
702.0	.95	0.	0.	0.	0.	0.	0.	0.	0.	0.	.95
703.0	1.00	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.00
704.0	1.05	0.	0.	0.	0.	0.		0.	0.	0.	1.05
705.0	1.05	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.05
706.0	1.15	0.	0.	0.	15.60	0.	0.	0.	0.	0.	16.75
707.0	1.25	0.	0.	0.	16.32	0.	0.	0.	0.	0.	17.57
708.0	1.35	0.	0.	0.	17.40	0.	0.	0.	0.	0.	18.75
709.0	1.45	0.	0.	0.	17.40	0.	0.	0.	.00	0.	18.85
710.0	1.60	0.	0.	0.	17.40	0.	0.	0.	.02	0.	19.02
711.0	1.95	0.	0.	0.	65.64	.01	0.	0.	.03	0.	67.63
712.0	2.10	0.	0.	0.	134.10	.04	0.	0.	.06	0.	136.30
713.0	2.30	0.	0.	0.	176.64	.05	0.	0.	.07	0.	179.06
714.0	2.80	0.	0.	0.	207.24	.06	0.	0.	.09	0.	210.19
715.0	3.20	0.	0.	0.	223.32	.15	0.	0.	.15	0.	226.82
716.0	3.55	0.	0.	0.	290.64	.24	0.	0.	.19	0.	294.62
717.0	3.70	0.	0.	0.	357.72	.29	0.	0.	.23	0.	361.94

718,0	3,80	0,	0,	0,	405,42	,33	0,	0,	,27	0,	409,82
719,0	4,00	0,	0,	0,	474,00	,36	0,	0,	,33	0,	478,70
720,0	4,15	0,	0,	0,	532,80	,39	0,	0,	,42	0,	537,76
721,0	4,20	0,	0,	0,	584,46	,41	0,	0,	,47	0,	589,94
722,0	4,25	0,	0,	0,	620,28	,41	0,	0,	,54	0,	625,48
723,0	4,60	0,	0,	0,	648,96	,41	0,	0,	,59	0,	654,56
724,0	4,75	0,	0,	0,	725,04	,45	0,	0,	,65	0,	730,89
725,0	5,10	0,	0,	0,	849,48	,50	0,	0,	,75	0,	855,82
706,6 (2 YEAR)	1,40	0,	0,	0,	17,40	0,	0,	0,	0,	0,	18,00
710,2 (10 YEAR)	1,60	0,	0,	0,	17,40	0,	0,	0,	,02	0,	19,02
710,8 (20 YEAR)	1,95	0,	0,	0,	49,32	0,	0,	0,	,03	0,	51,30
711,5 (50 YEAR)	2,05	0,	0,	0,	106,80	,03	0,	0,	,05	0,	108,92
711,9 (100 YEAR)	2,10	0,	0,	0,	129,36	,04	0,	0,	,06	0,	131,55

DAMAGE CATEGORY	LAND USE CODE	LAND USE
1	1	NATURAL VEGETATION
2	2	DEVELOPED OPEN SPACE
3	3	LOW DENSITY HOUSING
4	4	MEDIUM DENSITY HOUSING
5	5	HIGH DENSITY HOUSING
6	6	AGRICULTURE
7	7	INDUSTRIAL
8	8	COMMERCIAL
9	9	PASTURE
10	10	WATER BODIES

EXHIBIT 4-3

SAMPLE PROBLEM

FLOOD PROOFING NEW DEVELOPMENT TO A SPECIFIED HEIGHT
ABOVE ZERO STAGE

SAMPLE PROBLEM

FLOOD PROOFING NEW DEVELOPMENT TO

A SPECIFIED HEIGHT ABOVE ZERO STAGE

Problem Statement

Calculate the damages that would result from the 2-year, 10-year, 20-year, 50-year and 100-year flood events if new development (1990 alternative land use pattern) in residential housing, commercial and industrial land uses is flood proofed to a depth of 3 feet (3 feet above zero stage). Request trace output for the medium density residential land use category in damage reach 1. (Table 1 is a listing of the data base file used in the Trail Creek Watershed).

Description of Input Requirements

The key input variable for assessing the above stated conditions is IPROF (J1.2), which designates flood proofing of specified new development a given depth above zero stage. The J5 card defines the land use categories of new development that will be flood proofed and the J6 card assigns the depth of flood proofing to each land use.

The completed coding sheets have been included in this sample problem.

Discussion of Results

The stage-damage function for only one land use category (land use category 4) is included in this sample output. (The stage-damage functions for the other land use categories are identical to those shown in Exhibit 4-2).

The trace output (page 15) indicates that the grid cells (of land use category 4) analyzed have been flood proofed to a dpeth of 3 feet above the corresponding zero stages (as shown by the printed information tabulated under the

columns labeled "Damage Funct. Stage" and "Damage"). The information at the bottom of page 15 also indicates the total number of grid cells that have been flood proofed to the specified depths (as specified on the J5 and J6 cards) within damage reaches 1 and 3. (In this case 16 grid cells in damage reach 1 and 4 grid cells in damage reach 3 were flood proofed under the above stated conditions).

A comparison of the aggregated damages (for damage reaches 1 and 3) of Exhibits 4-2 and 4-3 shows the following:

- For damage reach 1 a significant reduction in damage occurs at the 2-year flood level whereas no reduction in damage results at the 10-year, 20-year 50-year and 100-year flood levels.

- For damage reach 3 a significant reduction in damage occurs at all of the flood event levels.

It should be noted that the level at which the damage reduction takes place is dependent on the elevation distribution of the grid cells being flood proofed.

TABLE 1

DATA BASE FILE DIRECTORY

FOR

THE TRAIL CREEK WATERSHED

Data Variable Code	Data Category Code	Identifying Title
1		GRID CELL ROW
	1	Row 1
	2-92	Rows 2-92
2		GRID CELL COLUMN
	1	Column 1
	2-129	Columns 2-129
3		WATERSHED
	1	Trail Creek
5		DAMAGE REACH
	1	Damage reach 1
	2-5	Damage reaches 2-5
10		EXISTING LAND USE
	1	Natural vegetation
	2	Developed open space
	3	Low density residential
	4	Medium density residential
	5	High density residential
	6	Agricultural
	7	Industrial
	8	Commercial
	9	Pasture
	10	Water bodies
11		1990 ALTERNATIVE LAND USE PATTERN
	1	Natural vegetation
	2	Developed open space
	3	Low density residential
	4	Medium density residential
	5	High density residential
	6	Agricultural
	7	Industrial
	8	Commercial
	9	Pasture
	10	Water bodies

TABLE 1 (continued)

DATA BASE FILE DIRECTORY

FOR

THE TRAIL CREEK WATERSHED

Data Variable Code	Data Category Code	Identifying Title
13		REFERENCE FLOOD ELEVATION Flood elevations to the nearest .1 foot are stored for each grid cell in the flood plain
14		TOPOGRAPHIC ELEVATION Land elevations to the nearest .1 foot are stored for each grid cell in the study area

GENERAL PURPOSE DATA FORM

(8 COLUMN FIELDS)

PROGRAM: DAMCAL - EXHIBIT 4-3 DATE: January 1979

REQUESTED BY: D. Gundlach PREPARED BY: CHECKED BY: PAGE: 1 of 4

	1	2	3	4	5	6	7	8	9	10
T1			SAMPLE PROBLEM						EXHIBIT 4-3	
T2			FLOOD PROOFING NEW DEVELOPMENT TO A SPECIFIED							
T3			HEIGHT ABOVE ZERO STAGE						JANUARY 1979	
J1	0	2	0	0	0	1	0	5	0	
J2	1	1	18	92	129	0				
J3	5	2	11	10	10	14	13	31		
J5	3	4	5	7	8					
J6	3	3	3	3	3					
JE	1	4								
ET(12F4.0,2F8.2,2F4.0,2F2.0)										
ST2 YEAR	10 YEAR	20 YEAR	50 YEAR	100 YEAR						
LU	1	0	1	0	0	0	1.00	3		
LT	1		NATURAL VEGETATION							
VF	-.01	0	10							
VD	0	.05	.05							
LU	2	1	1	0	0	100	1.00	3		
LT	2		DEVELOPED OPEN SPACE							
VF	-.01	0	10							
VS	0	0	0							
VC	0	0	0							
VD	0	100	100							
LU	3	1	1.0	25000	7500	-	.60	16		
LT	3		LOW DENSITY HOUSING							
DF	-2.01	-2	-1	0	1	2	3	4	5	6
DF	7	8	9	10	11	12				
DS	0	1	1	10	13	20	27	30	33	35
DS	36	40	41	41	45	45				
DC	0	0	0	2	33	59	66	73	77	80
DC	81	81	81	81	81	81				
DD	0	5	5	5	5	5	5	5	5	5

GENERAL PURPOSE DATA FORM

(8 COLUMN FIELDS)

PROGRAM: QAMCAL - EXHIBIT 4-3 DATE: January 1979

REQUESTED BY: D. Gundlach PREPARED BY: CHECKED BY: PAGE 2 of 4

	1	2	3	4	5	6	7	8	9	10
[illegible]	5	5	5	5	5	5				
LD	4	1	4	10000	-.30	-	.70	24		
LT	4	MEDIUM DENSITY HOUSING								
DF	-2.01	-2	-1	0	1	2	3	4	5	6
DF	7	8	9	10	11	12	13	14	15	16
DF	17	18	19	20						
DS	0	1	2	9	11	18	24	26	29	31
DS	32	35	36	36	[illegible]	40	41	42	43	44
DS	44	45	45	45						
DC	0	0	0	2	30	48	58	64	68	70
DC	71	71	73	74	74	74	74	74	74	74
DC	74	74	74	74						
[illegible]	0	5	5	5	5	5	5	5	5	4
[illegible]	4	4	4	4	3	3	3	3	3	2
[illegible]	2	2	2	2						
LD	5	1	12	50000	-.30	-	1.00	24		
LT	5	HIGH DENSITY HOUSING								
DF	-5.01	-5	-4	-3	-2	-1	0	1	2	3
DF	4	5	6	7	8	9	10	11	12	13
DF	14	15	16	17						
DS	0	2	2	2	2	2	2	9	13	17
DS	20	21	23	24	26	33	37	41	43	45
DS	46	48	50	50						
DC	0	2	2	3	3	3	3	25	57	71
DC	46	47	48	48	48	52	62	67	71	74
DC	75	75	75	75						
[illegible]	0	5	5	5	5	5	5	5	5	5
[illegible]	5	5	5	5	5	5	5	5	5	5
[illegible]	5	5	5	5						
[illegible]	6	1	1	120	6	-	1.00	10		

Exhibit 4-3
6 of 19

GENERAL PURPOSE DATA FORM

(8 COLUMN FIELDS)

PROGRAM: DAMCAL - EXHIBIT 4-3 DATE: January 1979

REQUESTED BY: D. Gundlach PREPARED BY: CHECKED BY: PAGE: 3 of 4

	1	2	3	4	5	6	7	8	9	10
LT	6.	AGRICULTURE								
DF	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
DS	0.	30.5	40.	48.	54.5	61.5	68.5	68.5	68.5	68.5
DC	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DP	0.	5.	5.	5.	5.	5.	5.	5.	5.	5.
LD	7.	1.	.2	590.000	885000	250000.	1.00	.20		
LT	7.	INDUSTRIAL								
DF	-2.01	-2.	-1.	0.	1.	2.	3.	4.	5.	6.
DF	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
DS	0.	1.	1.	2.	12.	18.	24.	27.	29.	31.
DS	32.	35.	38.	40.	44.	44.	45.	45.	46.	47.
DC	0.	0.	0.	5.	20.	37.	43.	49.	55.	57.
DC	63.	67.	71.	75.	81.	85.	85.	85.	85.	85.
DP	0.	0.	0.	5.	15.	20.	22.	30.	45.	50.
DP	55.	60.	65.	90.	95.	95.	95.	95.	95.	95.
LD	8.	1.	4.	50000.	-.60	-.	.80	15.		
LT	8.	COMMERCIAL								
DF	-5.01	-5.	0.	1.	2.	3.	4.	5.	6.	7.
DF	8.	9.	10.	11.	12.					
DS	0.	1.	10.	14.	20.	27.	30.	33.	35.	36.
DS	40.	41.	41.	45.	45.					
DC	0.	0.	2.	33.	54.	64.	73.	77.	80.	81.
DC	81.	81.	81.	81.	81.					
DP	0.	5.	5.	5.	5.	5.	5.	[illegible]	5.	5.
DP	5.	5.	5.	5.	5.					
LD	9.	1.	4.	120.	0.	-.	1.00	8.		
LT	9.	PASTURE								
DF	0.	1.	2.	3.	4.	5.	6.	7.		
DS	0.	9.	10.	12.	14.	16.	18.	18.		
DC	0.	0.	0.	0.	0.	0.	0.	0.		

GENERAL PURPOSE DATA FORM
(8 COLUMN FIELDS)

PROGRAM DAMCAL - EXHIBIT 4-3 DATE January 1979
REQUESTED BY D. Gundlach PREPARED BY CHECKED BY PAGE 4 OF 4

1	2	3	4	5	6	7	8	9	10
DI 0	5	5	5	5	5	5	5		
LV 10	1	1	0	0	0	1.00	2		
LT 10	WATER BODIES								
DE 0	10								
RS 0	0								
RC 0	0								
DO 0	0								
CR 1	634				610	1	0	0	
DT DAMAGE REACH 1-OCONEE TO CONFLUENCE									
SE 616.7	623.5	624.0	625.6	627.1					
DR 3	714				695	1	0	0	
DT DAMAGE REACH 3-LAST SECTION OF WEST FORK									
SE 708.6	710.2	710.8	711.5	711.9					
END									

Exhibit 4-3
8 of 19

```
                              SAMPLE PROBLEM                                          EXHIBIT 4-3
                              FLOOD PROOFING NEW DEVELOPMENT TO A SPECIFIED
                              HEIGHT ABOVE ZERO STAGE                                 JANUARY 1979


               J1 CARD
               -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
    J1      0       2       0       0       0       1       0       3       0
               IPOL     =     0, THERE IS NO POLICY CONTROL IN THIS RUN

               IPROP    =     2, SPECIFIED NEW DEVELOPMENT WILL BE FLOOD PROOFED THE RESPECTIVE
                                 AMOUNT IN RELATION TO THE GROUND LEVEL

               IEVAC    =     0, THERE IS NO PERMANENT EVACUATION IN THIS RUN

               IEVCLU   =     0, THERE IS NO PERMANENT EVACUATION IN THIS RUN

               IPRNT    =     0, NORMAL PRINTOUT

               ITRACE   =     1, TRACE OUTPUT REQUESTED

               IAUTO    =     0, NO FILE CREATED FOR ATODTA PROGRAM

               ITYPE    =     5, NUMBER OF SINGLE EVENT DAMAGES TO BE CALCULATED

               IAG      =     0, NO AGGREGATION OF SINGLE EVENT DAMAGES


               J2 CARD
               -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
    J2      1       1      10      92     129       0

               DATA BANK INFORMATION
               ---------------------

               NFILE    =     1, THE DATA BANK IS ON THIS COMPUTER UNIT

               NFORM    =     1, THE DATA BANK IS FORMATTED

               NOV      =    10, THE NUMBER OF DATA VARIABLES

               IROW     =    92, THE NUMBER OF ROWS IN THE DATA BANK

               ICOL     =   129, THE NUMBER OF COLUMNS IN THE DATA BANK

               IMAGE    =     0, NO PRINTED IMAGE OF INPUT DECK
```

```
                      J3 CARD
                      -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J3    5    2     11     10     10     14     13     31

                      DATA VARIABLE INFORMATION
                      -------------------------

                      IDAMRC  =    5, THE DATA VARIABLE THAT IS THE DAMAGE REACH CODE

                      NODR    =    2, THE NUMBER OF DAMAGE REACHES IN THIS ANALYSIS

                      ILAND   =   11, THE DATA VARIABLE THAT IS THE LAND USE ANALYZED

                      IBASE   =   10, THE DATA VARIABLE CONSIDERED THE BASE CONDITION

                      NOLUC   =   10, THE NUMBER OF LAND USE CATEGORIES

                      ITOPO   =   14, THE DATA VARIABLE THAT IS TOPOGRAPHY

                      IRFFD   =   13, THE DATA VARIABLE THAT IS THE REFERENCE FLOOD ELEVATION

                      IELV    =   31, THE NUMBER OF ELEVATION-DAMAGE POINTS TO BE CALCULATED


                      J5 CARD(S)             THE FOLLOWING LAND USE CATEGORIES WITH NEW
                      ----------             DEVELOPMENT ARE SUBJECT TO FLOOD PROOFING
                                             -----------------------------------------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J5    3    4    5    7    8


                      J6 CARD(S)             THE FLOOD PROOFED CATEGORIES WILL BE PROTECTED THE
                      ----------             CORRESPONDING FEET IN RELATION TO THE GROUND FLOOR
                                             --------------------------------------------------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J6  3.00    3.00    3.00    3.00    3.00


                      J8 CARD
                      -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J8    1    4

                      TRACE INFORMATION
                      -----------------

                      NNDR    =    1, TRACE OUTPUT PROVIDED IN THIS DAMAGE REACH

                      NNLU    =    4, TRACE OUTPUT PROVIDED FOR THIS LAND USE CATEGORY


                      FORMAT CARD
                      -----------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   FT(12F4.0,8F6.2,2F4.0,2F8.0)
```

Several pages of printout deleted relating to the stage-damage functions for particular land use categories (stage-damage functions are identical to those shown in Exhibit 4-2 for the ten land use categories)

SAMPLE PROBLEM
FLOOD PROOFING NEW DEVELOPMENT TO A SPECIFIED
HEIGHT ABOVE ZERO STAGE

EXHIBIT 4-3
JANUARY 1979

LAND USE CATEGORY NO. 4

MEDIUM DENSITY HOUSING

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-2.01	0.	0.	0.	0.
-2.00	1.00	0.	5.00	.28
-1.00	2.00	0.	5.00	.56
0.	9.00	2.00	5.00	2.69
1.00	11.00	30.00	5.00	5.60
2.00	18.00	48.00	5.00	9.07
3.00	24.00	58.00	5.00	11.59
4.00	26.00	64.00	5.00	12.66
5.00	29.00	68.00	5.00	13.83
6.00	31.00	70.00	4.00	14.56
7.00	32.00	71.00	4.00	14.92
8.00	35.00	71.00	4.00	15.76
9.00	36.00	73.00	4.00	16.21
10.00	36.00	74.00	4.00	16.30
11.00	40.00	74.00	3.00	17.42
12.00	40.00	74.00	3.00	17.42
13.00	41.00	74.00	3.00	17.70
14.00	42.00	74.00	3.00	17.98
15.00	43.00	74.00	3.00	18.26
16.00	44.00	74.00	2.00	18.54
17.00	45.00	74.00	2.00	18.82
18.00	45.00	74.00	2.00	18.82
19.00	45.00	74.00	2.00	18.82
20.00	45.00	74.00	2.00	18.82

DENSITY OF THE LAND USE UNITS PER GRID CELL = 4.00

BASE VALUE OF THE STRUCTURE = 10000.00

BASE VALUE OF THE CONTENTS (30.00 PERCENT OF THE STRUCTURE VALUE) = 3000.00

BASE VALUE OF OTHER = -0.

VACANCY FACTOR (PERCENT DEVELOPED) = 70.0

ONLY NEW DEVELOPMENT IN THIS LAND USE WILL BE FLOOD PROOFED 3.0 FEET

Several pages of printout deleted relating to the stage-damage functions for particular land use categories (stage-damage functions are identical to those shown in Exhibit 4-2 for the ten land use categories)

SAMPLE PROBLEM
FLOOD PROOFING NEW DEVELOPMENT TO A SPECIFIED
HEIGHT ABOVE ZERO STAGE

EXHIBIT 4-3
JANUARY 1979

DAMAGE REACH INDEX LOCATION SUMMARY

ID. NO.	REFERENCE FLOOD ELEVATION	POLICY FLOOD ELEVATION	FLOOD PROOFING ELEVATION	EVACUATION ELEVATION	STARTING DAMAGE ELEVATION	DAMAGE ELEVATION INCREMENT	AGGREGATED DAMAGE RCH. ID.	MODIFY LAND USE DENSITY
1.	634.0	0.	0.	0.	610.0	1.00	0	0
3.	714.0	0.	0.	0.	695.0	1.00	0	0

SINGLE EVENTS FOR DAMAGE REACHES

DAMAGE REACH NO.	2 YEAR EVENT	10 YEAR EVENT	20 YEAR EVENT	50 YEAR EVENT	100 YEAR EVENT
1.	616.7	623.5	624.0	625.6	627.1
3.	708.6	710.2	710.8	711.5	711.9

DAMAGE REACH 1 IS BEING TRACED FOR LAND USE 4

* INDICATES ELEVATION IS AT GRID CELL

ROW	COL	ARRAY INDEX	BASE L.U.	ALT. L.U.	*REF. FLOOD ELEV.	* POLICY ELEV.	*TOPO BEFORE POLICY	*TOPO AFTER POLICY	FLOOD PROOF ELEV.	* EVAC. ELEV.	DAMAGE FUNCT. STAGE	DAMAGE ELEV.	DAMAGE	ACCUM. DAMAGE
80	7	2	2	4	620.00	0.	600.00	600.00	0.	0.	-3.00	611.00	0.	0.
80	7	3	2	4	620.00	0.	600.00	600.00	0.	0.	-2.00	612.00	0.	0.
80	7	4	2	4	620.00	0.	600.00	600.00	0.	0.	-1.00	613.00	0.	0.
80	7	5	2	4	620.00	0.	600.00	600.00	0.	0.	0.	614.00	0.	0.
80	7	6	2	4	620.00	0.	600.00	600.00	0.	0.	1.00	615.00	0.	0.
80	7	7	2	4	620.00	0.	600.00	600.00	0.	0.	2.00	616.00	0.	0.
80	7	8	2	4	620.00	0.	600.00	600.00	0.	0.	3.00	617.00	0.	0.
80	7	9	2	4	620.00	0.	600.00	600.00	0.	0.	4.00	618.00	12.66	12.66
80	7	10	2	4	620.00	0.	600.00	600.00	0.	0.	5.00	619.00	13.63	13.63
80	7	11	2	4	620.00	0.	600.00	600.00	0.	0.	6.00	620.00	14.56	14.56
80	7	12	2	4	620.00	0.	600.00	600.00	0.	0.	7.00	621.00	14.92	14.92
80	7	13	2	4	620.00	0.	600.00	600.00	0.	0.	8.00	622.00	15.76	15.76
80	7	14	2	4	620.00	0.	600.00	600.00	0.	0.	9.00	623.00	16.21	16.21
80	7	15	2	4	620.00	0.	600.00	600.00	0.	0.	10.00	624.00	16.30	16.30
80	7	16	2	4	620.00	0.	600.00	600.00	0.	0.	11.00	625.00	17.42	17.42
80	7	17	2	4	620.00	0.	600.00	600.00	0.	0.	12.00	626.00	17.42	17.42
80	7	18	2	4	620.00	0.	600.00	600.00	0.	0.	13.00	627.00	17.70	17.70
80	7	19	2	4	620.00	0.	600.00	600.00	0.	0.	14.00	628.00	17.98	17.98
80	7	20	2	4	620.00	0.	600.00	600.00	0.	0.	15.00	629.00	18.26	18.26
80	7	21	2	4	620.00	0.	600.00	600.00	0.	0.	16.00	630.00	18.54	18.54
80	7	22	2	4	620.00	0.	600.00	600.00	0.	0.	17.00	631.00	18.82	18.82
80	7	23	2	4	620.00	0.	600.00	600.00	0.	0.	18.00	632.00	18.82	18.82
80	7	24	2	4	620.00	0.	600.00	600.00	0.	0.	19.00	633.00	18.82	18.82
80	7	25	2	4	620.00	0.	600.00	600.00	0.	0.	20.00	634.00	18.82	18.82
80	7	26	2	4	620.00	0.	600.00	600.00	0.	0.	21.00	635.00	18.82	18.82
80	7	27	2	4	620.00	0.	600.00	600.00	0.	0.	22.00	636.00	18.82	18.82
80	7	28	2	4	620.00	0.	600.00	600.00	0.	0.	23.00	637.00	18.82	18.82
80	7	29	2	4	620.00	0.	600.00	600.00	0.	0.	24.00	638.00	18.82	18.82
80	7	30	2	4	620.00	0.	600.00	600.00	0.	0.	25.00	639.00	18.82	18.82
80	7	31	2	4	620.00	0.	600.00	600.00	0.	0.	26.00	640.00	18.82	18.82
80	8	22	2	4	620.00	0.	620.00	620.00	0.	0.	-3.00	631.00	0.	18.82
80	8	23	2	4	620.00	0.	620.00	620.00	0.	0.	-2.00	632.00	0.	18.82
80	8	24	2	4	620.00	0.	620.00	620.00	0.	0.	-1.00	633.00	0.	18.82
80	8	25	2	4	620.00	0.	620.00	620.00	0.	0.	0.	634.00	0.	18.82
80	8	26	2	4	620.00	0.	620.00	620.00	0.	0.	1.00	635.00	0.	18.82
80	8	27	2	4	620.00	0.	620.00	620.00	0.	0.	2.00	636.00	0.	18.82
80	8	28	2	4	620.00	0.	620.00	620.00	0.	0.	3.00	637.00	0.	18.82
80	8	29	2	4	620.00	0.	620.00	620.00	0.	0.	4.00	638.00	12.66	31.47
80	8	30	2	4	620.00	0.	620.00	620.00	0.	0.	5.00	639.00	13.63	32.45
80	8	31	2	4	620.00	0.	620.00	620.00	0.	0.	6.00	640.00	14.56	33.38

DAMAGE REACH 1 HAS 16. CELLS THAT WERE FLOOD PROOFED TO SPECIFIED LEVELS
DAMAGE REACH 3 HAS 4. CELLS THAT WERE FLOOD PROOFED TO SPECIFIED LEVELS

DAMAGE REACH 3 HAS 12. CELLS WITH DAMAGES STARTING BELOW THE STARTING AGGREGATION ELEVATION

DAMAGE REACH 1 HAS 160. CELLS WITH DAMAGES STARTING ABOVE THE HIGHEST AGGREGATION ELEVTION
DAMAGE REACH 3 HAS 137. CELLS WITH DAMAGES STARTING ABOVE THE HIGHEST AGGREGATION ELEVTION

SAMPLE PROBLEM EXHIBIT 4-3
FLOOD PROOFING NEW DEVELOPMENT TO A SPECIFIED
HEIGHT ABOVE ZERO STAGE JANUARY 1979
DAMAGE REACH NO. 1

DAMAGE REACH 1-OCONEE TO CONFLUENCE

LAND USE CATEGORIES

WATER SURFACE ELEVATION	1	2	3	4	5	6	7	8	9	10	TOTAL
610.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
611.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
612.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
613.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
614.0	.15	0.	0.	0.	0.	0.	0.	0.	0.	0.	.15
615.0	.15	0.	0.	0.	0.	0.	0.	0.	.07	0.	.22
616.0	.15	0.	0.	0.	0.	0.	0.	0.	.10	0.	.25
617.0	.20	0.	0.	0.	0.	0.	0.	0.	.12	0.	.32
618.0	.25	0.	0.	12.66	0.	0.	935.13	0.	.15	0.	948.18
619.0	.25	0.	0.	13.53	0.	0.	1078.49	0.	.18	0.	1092.75
620.0	.35	0.	0.	14.56	0.	0.	1162.07	0.	.25	0.	1177.83
621.0	.40	0.	0.	14.92	0.	0.	1330.90	0.	.27	0.	1346.90
622.0	.45	0.	0.	15.76	0.	0.	1547.16	0.	.29	0.	1563.66
623.0	.45	0.	0.	16.21	0.	0.	1653.50	0.	.31	0.	1670.47
624.0	.55	.30	0.	16.30	0.	0.	1748.19	0.	.33	0.	1765.67
625.0	.55	.30	0.	17.42	0.	0.	1892.48	0.	.39	0.	1911.14
626.0	.55	.30	0.	17.42	0.	0.	1958.16	0.	.41	0.	1976.84
627.0	.70	.30	0.	17.70	0.	0.	1978.72	0.	.43	0.	1997.84
628.0	[illegible]	.40	0.	17.98	0.	0.	1996.79	0.	.46	0.	2014.43
629.0	.90	.40	0.	18.26	0.	0.	2013.36	0.	.49	0.	2033.40
630.0	1.10	.40	0.	18.54	0.	0.	2024.87	0.	.52	0.	2045.18
631.0	1.15	.40	0.	18.82	0.	0.	2024.92	0.	.55	0.	2045.84
632.0	1.15	.40	0.	18.82	0.	0.	2025.75	0.	.56	0.	2046.69

633.0	1.25	.40	0.	18.82	0.	0.	2026.93	0.	.64	0.	2048.03
634.0	1.80	1.00	0.	18.82	0.	0.	2027.28	0.	.71	0.	2049.60
635.0	1.80	1.00	0.	18.82	0.	0.	2027.28	0.	.89	0.	2049.79
636.0	1.80	1.00	0.	18.82	0.	0.	2027.28	0.	.95	0.	2049.85
637.0	1.80	1.00	0.	18.82	0.	0.	2027.28	0.	1.04	0.	2049.94
638.0	1.80	1.00	0.	31.47	0.	0.	2027.28	472.32	1.13	0.	2535.00
639.0	1.85	1.00	0.	32.65	0.	0.	2027.28	506.88	1.21	0.	2570.87
640.0	1.90	1.00	0.	33.38	0.	0.	2027.28	531.80	1.28	0.	2596.64
616.7 (2 YEAR)	.20	0.	0.	0.	0.	0.	0.	0.	.12	0.	.32
623.5 (10 YEAR)	.45	.10	0.	16.25	0.	0.	1701.02	0.	.32	0.	1718.14
624.0 (20 YEAR)	.55	.30	0.	16.30	0.	0.	1748.19	0.	.33	0.	1765.67
625.6 (50 YEAR)	.55	.30	0.	17.42	0.	0.	1933.09	0.	.40	0.	1951.76
627.1 (100 YEAR)	.70	.40	0.	17.72	0.	0.	1979.91	0.	.43	0.	1999.17

DAMAGE CATEGORY	LAND USE CODE	LAND USE
1	1	NATURAL VEGETATION
2	2	DEVELOPED OPEN SPACE
3	3	LOW DENSITY HOUSING
4	4	MEDIUM DENSITY HOUSING
5	5	HIGH DENSITY HOUSING
6	6	AGRICULTURE
7	7	INDUSTRIAL
8	8	COMMERCIAL
9	9	PASTURE
10	10	WATER BODIES

SAMPLE PROBLEM
FLOOD PROOFING NEW DEVELOPMENT TO A SPECIFIED
HEIGHT ABOVE ZERO STAGE
DAMAGE RE-CH NO. 3

EXHIBIT 4-3
JANUARY 1979

DAMAGE REACH 3-LAST SECTION OF WEST FORK

LAND USE CATEGORIES

WATER SURFACE ELEVATION	1	2	3	4	5	6	7	8	9	10	TOTAL
695.0	.60	0.	0.	0.	0.	0.	0.	0.	0.	0.	.60
696.0	.70	0.	0.	0.	0.	0.	0.	0.	0.	0.	.70
697.0	.75	0.	0.	0.	0.	0.	0.	0.	0.	0.	.75
698.0	.75	0.	0.	0.	0.	0.	0.	0.	0.	0.	.75
699.0	.80	0.	0.	0.	0.	0.	0.	0.	0.	0.	.80
700.0	.85	0.	0.	0.	0.	0.	0.	0.	0.	0.	.85
701.0	.90	0.	0.	0.	0.	0.	0.	0.	0.	0.	.90
702.0	.95	0.	0.	0.	0.	0.	0.	0.	0.	0.	.95
703.0	1.00	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.00
704.0	1.05	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.05
705.0	1.05	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.05
706.0	1.15	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.15
707.0	1.25	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.25
708.0	1.35	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.35
709.0	1.45	0.	0.	0.	0.	0.	0.	0.	.00	0.	1.45
710.0	1.60	0.	0.	0.	0.	0.	0.	0.	.02	0.	1.62
711.0	1.95	0.	0.	0.	0.	.01	0.	0.	.03	0.	1.99
712.0	2.10	0.	0.	0.	0.	.04	0.	0.	.06	0.	2.20
713.0	2.30	0.	0.	0.	0.	.05	0.	0.	.07	0.	2.42
714.0	2.80	0.	0.	0.	81.12	.06	0.	0.	.09	0.	84.07
715.0	3.20	0.	0.	0.	205.92	.15	0.	0.	.15	0.	209.42
716.0	3.55	0.	0.	0.	216.12	.24	0.	0.	.19	0.	220.10
717.0	3.70	0.	0.	0.	226.80	.29	0.	0.	.23	0.	231.02

718.0	3.80	0.	0.	0.	235.20	.33	0.	0.	.27	0.	239.60
719.0	4.00	0.	0.	0.	404.04	.36	0.	0.	.33	0.	408.74
720.0	4.15	0.	0.	0.	516.66	.39	0.	0.	.42	0.	521.62
721.0	4.20	0.	0.	0.	567.06	.41	0.	0.	.47	0.	572.14
722.0	4.25	0.	0.	0.	602.88	.41	0.	0.	.54	0.	608.08
723.0	4.60	0.	0.	0.	631.56	.41	0.	0.	.59	0.	637.16
724.0	4.75	0.	0.	0.	683.16	.45	0.	0.	.65	0.	689.01
725.3	5.10	0.	0.	0.	736.80	.50	0.	0.	.75	0.	743.14
708.6 (2 YEAR)	1.40	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.40
710.2 (10 YEAR)	1.60	0.	0.	0.	0.	0.	0.	0.	.02	0.	1.62
710.8 (20 YEAR)	1.95	0.	0.	0.	0.	0.	0.	0.	.03	0.	1.98
711.5 (50 YEAR)	2.05	0.	0.	0.	0.	.03	0.	0.	.05	0.	2.12
711.9 (100 YEAR)	2.10	0.	0.	0.	0.	.04	0.	0.	.06	0.	2.19

DAMAGE CATEGORY	LAND USE CODE	LAND USE
1	1	NATURAL VEGETATION
2	2	DEVELOPED OPEN SPACE
3	3	LOW DENSITY HOUSING
4	4	MEDIUM DENSITY HOUSING
5	5	HIGH DENSITY HOUSING
6	6	AGRICULTURE
7	7	INDUSTRIAL
8	8	COMMERCIAL
9	9	PASTURE
10	10	WATER BODIES

EXHIBIT 4-4

SAMPLE PROBLEM

FLOOD PROOFING NEW DEVELOPMENT TO THE EXISTING 100-YEAR FLOOD LEVEL

SAMPLE PROBLEM

FLOOD PROOFING NEW DEVELOPMENT TO THE EXISTING 100-YEAR FLOOD LEVEL

Problem Statement

Flood proof new development (1990 alternative land use pattern) in residential housing, commercial and industrial land uses to the existing 100-year flood level. (In this case the 100-year flood level for the existing or base land use pattern is assumed to be the same as the 100-year level for the 1990 land use pattern. If possible, the user should estimate flood levels for future conditions and input those levels when analyzing future alternatives). Request trace output for the medium density residential land use category in damage reach 1 and obtain damage values for the 2-year, 10-year, 20-year, 50-year and 100-year flood events. (Table 1 is a listing of the data base file used in the Trail Creek Watershed).

Description of Input Requirements

The key input variable for assessing the above stated conditions is IPROF (J1.2), to indicate flood proofing of new development to a specified level. The J5 card is used to designate the land use categories to be protected and the 100-year flood protection elevation is input on the DR card (the 100-year elevation on the DR card should correspond to the 100-year elevation on the SE card).

The completed coding sheets have been included in this sample problem.

Discussion of Results

An inspection of the trace output shows that land use category 4 in damage reach 1 is flood proofed to the 100-year level (no damage results until the 100-year flood event elevation at the index location is exceeded). In this

case the 100-year flood elevation at the index location is 627.1 feet and as shown by the column labeled "Damage" no damage occurs until an elevation of 628 feet is reached.

The note printed below the trace information reveals the total number of grid cells in damage reaches 1 and 3 that were flood proofed to the specified target level.

A comparison of the aggregated damage tables of Exhibits 4-2 and 4-4, show a significant reduction in damage up to the 100-year flood event levels specified due to this flood proofing option. The user can check the accuracy of this flood proofing option since all aggregated damage values (of this sample problem) above the target protection level specified should agree with the corresponding values shown in Exhibit 4-2.

TABLE 1

DATA BASE FILE DIRECTORY

FOR

THE TRAIL CREEK WATERSHED

Data Variable Code	Data Category Code	Identifying Title
1		GRID CELL ROW
	1	Row 1
	2-92	Rows 2-92
2		GRID CELL COLUMN
	1	Column 1
	2-129	Columns 2-129
3		WATERSHED
	1	Trail Creek
5		DAMAGE REACH
	1	Damage reach 1
	2-5	Damage reaches 2-5
10		EXISTING LAND USE
	1	Natural vegetation
	2	Developed open space
	3	Low density residential
	4	Medium density residential
	5	High density residential
	6	Agricultural
	7	Industrial
	8	Commercial
	9	Pasture
	10	Water bodies
11		1990 ALTERNATIVE LAND USE PATTERN
	1	Natural vegetation
	2	Developed open space
	3	Low density residential
	4	Medium density residential
	5	High density residential
	6	Agricultural
	7	Industrial
	8	Commercial
	9	Pasture
	10	Water bodies

TABLE 1 (continued)

DATA BASE FILE DIRECTORY

FOR

THE TRAIL CREEK WATERSHED

Data Variable Code	Data Category Code	Identifying Title
13		REFERENCE FLOOD ELEVATION Flood elevations to the nearest .1 foot are stored for each grid cell in the flood plain
14		TOPOGRAPHIC ELEVATION Land elevations to the nearest .1 foot are stored for each grid cell in the study area

GENERAL PURPOSE DATA FORM

(8 COLUMN FIELDS)

PROGRAM DAMCAL - EXHIBIT 4-1 DATE January 1979

REQUESTED BY D. Gundlach PREPARED BY CHECKED BY PAGE 1 of 4

1	2	3	4	5	6	7	8	9	10
T1		SAMPLE PROBLEM						EXHIBIT 4-4	
T2		FLOOD PROOFING NEW DEVELOPMENT TO THE EXISTING							
T3		100-YEAR FLOOD LEVEL						JANUARY 1979	
J1 0	4	0	0	0	1	0	5	0	
J2 1	1	18	92	129	0				
J3 5	2	11	10	10	14	13	31		
J5 3	7	5	7	8					
J8 1	4								
FT(12F4.0,2F8.2,2F4.0,2F2.0)									
ST2 YEAR 10 YEAR 20 YEAR 50 YEAR100 YEAR									
LU 1	0	1	0	0	0	1.00	3		
LT 1		NATURAL VEGETATION							
DE -.01	0	10							
MD 0	.05	.05							
LU 2	1	1	0	0	100	1.00	3		
LT 2		DEVELOPED OPEN SPACE							
DE -.01	0	10							
DS 0	0	0							
DC 0	0	0							
PD 0	100	100							
LU 3	1	1.0	25000	7500	-	.60	16		
LT 3		LOW DENSITY HOUSING							
DE -2.01	-2	-1	0	1	2	3	4	5	6
DE 7	8	9	10	11	12				
DS 0	1	1	10	13	20	27	30	33	35
DS 36	40	41	41	45	45				
DC 0	0	0	2	33	59	66	73	77	80
DC 81	81	81	81	81	81				
PD 0	5	5	5	5	5	5	5	5	5

GENERAL PURPOSE DATA FORM

(8 COLUMN FIELDS)

PROGRAM: DAMCAL - EXHIBIT 4-4

DATE: January 1979

REQUESTED BY: D. Gundlach

PREPARED BY:

CHECKED BY:

PAGE: 2 of 4

	1	2	3	4	5	6	7	8	9	10
DQ	5.	5.	5.	5.	5.	5				
LD	4.	1.	4.	10000.	-.30.	-.	.70	24		
LT	4.	MEDIUM DENSITY HOUSING								
DE	-2.01	-2.	-1.	0.	1.	2.	3.	4.	5.	6
DE	7.	8.	9.	10	11.	12.	13.	14	15	16
DE	17.	18.	19.	20						
DS	0.	1.	2.	9.	11.	18.	24	26.	29.	31
DS	32.	35.	36	36	40	40	41.	42.	43	44
DS	45	45	45.	45						
DC	0	0	0.	2	30	48	58	64	68	70
DC	71.	71.	73.	74.	74	74.	74.	74	74	74
DC	74	74	74	74						
DQ	0.	5.	5.	5.	5.	5	5.	5	5	4
DQ	4	4.	4.	4	3.	3.	3.	3.	3	2
DQ	2.	2.	2	2						
LD	5.	1.	12.	50000.	-.30	-.	1.00	24		
LT	5.	HIGH DENSITY HOUSING								
DE	-5.01	-5	-4.	-3	-2	-1.	0.	1.	2.	3.
DE	4.	5.	6.	7.	8.	9.	10.	11.	12.	13
DE	14	15.	16.	17.						
DS	0	2.	2.	2.	2.	2	2.	9.	13.	17
DS	20.	21.	23	24	26.	33	37	41.	43	45
DS	46.	48	50	50						
DC	0	2.	2.	3	3	3.	3	25	37.	44
DC	46.	47.	48.	48	48	52.	62.	67.	71.	74
DC	75.	75	75	75						
DQ	0.	5.	5	5	5	5.	5.	5	5.	5
DQ	5.	5.	5.	5.	5	5.	5.	5	5.	5
DQ	5.	5.	5.	5.						
LD	6	1	1	120	0	-	1.00	10		

GENERAL PURPOSE DATA FORM
(8 COLUMN FIELDS)

PROGRAM DAMCAL - EXHIBIT 4-4 DATE January 1979

REQUESTED BY D. Gundlach PREPARED BY CHECKED BY PAGE 3 OF 4

	1	2	3	4	5	6	7	8	9	10
LT	6		AGRICULTURE							
DF	0	1	2	3	4	5	6	7	8	9
DS	0	30.5	40	48	54.5	61.5	68.5	68.5	68.5	68.5
DC	0	0	0	0	0	0	0	0	0	0
DD	0	5	5	5	5	5	5	5	5	5
LU	7	1	.2	590000	885000	250000	1.00	20		
LT	7		INDUSTRIAL							
DF	-2.01	-2	-1	0	1	2	3	4	5	6
DF	7	8	9	10	11	12	13	14	15	16
DS	0	1	1	4	12	18	24	27	29	31
DS	32	35	38	40	44	44	45	45	46	47
DC	0	0	0	5	28	37	43	49	55	59
DC	63	67	71	75	81	85	85	85	85	85
DD	0	0	0	5	15	20	22	30	45	50
DD	55	80	85	90	95	95	95	95	95	95
LU	8	1	4	50000	-.60	-	.80	15		
LT	8		COMMERCIAL							
DF	-5.01	-5	0	1	2	3	4	5	6	7
DF	8	9	10	11	12					
DS	0	1	10	14	20	27	30	33	35	36
DS	40	41	41	45	45					
DC	0	0	2	33	54	66	73	77	80	81
DC	81	81	81	81	81					
DD	0	5	5	5	5	5	5	5	5	5
DD	5	5	5	5	5					
LU	9	1	1	120	0	-	1.00	8		
LT	9		PASTURE							
DF	0	1	2	3	4	5	6	7		
DS	0	9	10	12	14	16	18	18		
DC	0	0	0	0	0	0	0	0		

GENERAL PURPOSE DATA FORM

(8 COLUMN FIELDS)

PROGRAM DAMCAL - EXHIBIT 4-4 DATE January 1979

REQUESTED BY D. Gundlach PREPARED BY CHECKED BY PAGE 4 OF 4

	1	2	3	4	5	6	7	8	9	10
DA	0	5	5	5	5	5	5	5		
LV	10	1	1	0	0	0	1.00	2		
LT	10		WATER BODIES							
DF	0	10								
DS	0	0								
DC	0	0								
DØ	0	0								
DR	1	634		627.1		610	1	0	0	
DT	DAMAGE REACH 1-OCONEE TO CONFLUENCE									
SE	616.7	623.5	624.0	625.6	627.1					
DR	3	714		711.9		695	1	0	0	
DT	DAMAGE REACH 3-LAST SECTION OF WEST FORK									
SE	708.6	710.2	710.8	711.5	711.9					
END										

```
SAMPLE PROBLEM                                               EXHIBIT 4-4
FLOOD PROOFING NEW DEVELOPMENT TO THE EXISTING
100-YEAR FLOOD LEVEL                                         JANUARY 1979


                  J1 CARD
                  -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J1      0       4       0       0       0       1       0       5       0
                  IPOL     =     0, THERE IS NO POLICY CONTROL IN THIS RUN

                  IPROF    =     4, SPECIFIED NEW DEVELOPMENT WILL BE FLOOD PROOFED TO A SPECIFIED LEVEL

                  IEVAC    =     0, THERE IS NO PERMANENT EVACUATION IN THIS RUN

                  IEVCLU   =     0, THERE IS NO PERMANENT EVACUATIUN IN THIS RUN

                  IPRNT    =     0, NORMAL PRINTOUT

                  ITRACE   =     1, TRACE OUTPUT REQUESTED

                  IAUTO    =     0, NO FILE CREATED FOR ATODTA PROGRAM

                  ITYPE    =     5, NUMBER OF SINGLE EVENT DAMAGES TO BE CALCULATED

                  IAG      =     0, NO AGGREGATION OF SINGLE EVENT DAMAGES


                  J2 CARD
                  -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J2      1       1      18      92     129       0

                  DATA BANK INFORMATION
                  ---------------------

                  NFILE    =      1, THE DATA BANK IS ON THIS COMPUTER UNIT

                  NFORM    =      1, THE DATA BANK IS FORMATTED

                  NDV      =     18, THE NUMBER OF DATA VARIABLES

                  IROW     =     92, THE NUMBER OF ROWS IN THE DATA BANK

                  ICOL     =    129, THE NUMBER OF COLUMNS IN THE DATA BANK

                  IMAGE    =      0, NO PRINTED IMAGE OF INPUT DECK
```

```
                     J3 CARD
                     =======
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J3    5    2    11   10   10   14   13   31

                     DATA VARIABLE INFORMATION
                     =========================

                     IDAMRC  =    5, THE DATA VARIABLE THAT IS THE DAMAGE REACH CODE

                     NDDR    =    2, THE NUMBER OF DAMAGE REACHES IN THIS ANALYSIS

                     ILAND   =   11, THE DATA VARIABLE THAT IS THE LAND USE ANALYZED

                     IBASE   =   10, THE DATA VARIABLE CONSIDERED THE BASE CONDITION

                     NOLUC   =   10, THE NUMBER OF LAND USE CATEGORIES

                     ITOPO   =   14, THE DATA VARIABLE THAT IS TOPOGRAPHY

                     IRFFD   =   13, THE DATA VARIABLE THAT IS THE REFERENCE FLOOD ELEVATION

                     IELV    =   31, THE NUMBER OF ELEVATION-DAMAGE POINTS TO BE CALCULATED


                                          THE FOLLOWING LAND USE CATEGORIES WITH NEW
                     J5 CARD(S)           DEVELOPMENT ARE SUBJECT TO FLOOD PROOFING
                     ==========           ==========================================
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J5    3    4    5    7    8


                     J8 CARD
                     =======
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J8    1    4

                     TRACE INFORMATION
                     =================

                     NNDR    =    1, TRACE OUTPUT PROVIDED IN THIS DAMAGE REACH

                     NNLU    =    4, TRACE OUTPUT PROVIDED FOR THIS LAND USE CATEGORY


                     FORMAT CARD
                     ===========
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   FT(12F4.0,2F8.2,2F4.0,2F2.0)
```

Several pages of printout deleted relating to the stage-damage functions for particular land use categories (stage-damage functions are identical to those shown in Exhibit 4-2 for the ten land use categories)

SAMPLE PROBLEM
FLOOD PROOFING NEW DEVELOPMENT TO THE EXISTING
100-YEAR FLOOD LEVEL

EXHIBIT 4-4
JANUARY 1979

LAND USE CATEGORY NO. 4

MEDIUM DENSITY HOUSING

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-2.01	0.	0.	0.	0.
-2.00	1.00	0.	5.00	.28
-1.00	2.00	0.	5.00	.56
0.	9.00	2.00	5.00	2.69
1.00	11.00	30.00	5.00	5.60
2.00	18.00	40.00	5.00	9.07
3.00	24.00	58.00	5.00	11.59
4.00	26.00	64.00	5.00	12.66
5.00	29.00	68.00	5.00	13.83
6.00	31.00	70.00	4.00	14.56
7.00	32.00	71.00	4.00	14.92
8.00	35.00	71.00	4.00	15.76
9.00	36.00	73.00	4.00	16.21
10.00	36.00	74.00	4.00	16.30
11.00	40.00	74.00	3.00	17.42
12.00	40.00	74.00	3.00	17.42
13.00	41.00	74.00	3.00	17.70
14.00	42.00	74.00	3.00	17.98
15.00	43.00	74.00	3.00	18.26
16.00	44.00	74.00	2.00	18.54
17.00	45.00	74.00	2.00	18.82
18.00	45.00	74.00	2.00	18.82
19.00	45.00	74.00	2.00	18.82
20.00	45.00	74.00	2.00	18.82

DENSITY OF THE LAND USE UNITS PER GRID CELL = 4.00

BASE VALUE OF THE STRUCTURE = 10000.00

BASE VALUE OF THE CONTENTS (30.00 PERCENT OF THE STRUCTURE VALUE) = 3000.00

BASE VALUE OF OTHER = -0.

VACANCY FACTOR (PERCENT DEVELOPED) = 70.0

ONLY NEW DEVELOPMENT IN THIS LAND USE WILL BE FLOOD PROOFED TO A SPECIFIED PROTECTION LEVEL

Several pages of printout deleted relating to the stage-damage functions for particular land use categories (stage-damage functions are identical to those shown in Exhibit 4-2 for the ten land use categories)

SAMPLE PROBLEM
FLOOD PROOFING NEW DEVELOPMENT TO THE EXISTING
100-YEAR FLOOD LEVEL

EXHIBIT 4-4
JANUARY 1979

DAMAGE REACH INDEX LOCATION SUMMARY

ID. NO.	REFERENCE FLOOD ELEVATION	POLICY FLOOD ELEVATION	FLOOD PROOFING ELEVATION	EVACUATION ELEVATION	STARTING DAMAGE ELEVATION	DAMAGE ELEVATION INCREMENT	AGGREGATED DAMAGE RCH. ID.	MODIFY LAND USE DENSITY
1.	634.0	0.	627.1	0.	610.0	1.00	0	0
3.	714.0	0.	711.9	0.	695.0	1.00	0	0

SINGLE EVENTS FOR DAMAGE REACHES

DAMAGE REACH NO.	2 YEAR EVENT	10 YEAR EVENT	20 YEAR EVENT	50 YEAR EVENT	100 YEAR EVENT
1.	616.7	623.5	624.0	625.6	627.1
3.	708.6	710.2	710.8	711.5	711.9

DAMAGE REACH 1 IS BEING TRACED FOR LAND USE 4

* INDICATES ELEVATION IS AT GRID CELL

ROW	COL	ARRAY INDEX	BASE L.U.	ALT. L.U.	*REF. FLOOD ELEV.	* POLICY ELEV.	*TOPO BEFORE POLICY	*TOPO AFTER POLICY	FLOOD PROOF ELEV.	* EVAC. ELEV.	DAMAGE FUNCT. STAGE	DAMAGE ELEV.	DAMAGE	ACCUM. DAMAGE
80	7	2	2	4	620.00	0.	600.00	600.00	627.10	0.	-3.00	611.00	0.	0.
80	7	3	2	4	620.00	0.	600.00	600.00	627.10	0.	-2.00	612.00	0.	0.
80	7	4	2	4	620.00	0.	600.00	600.00	627.10	0.	-1.00	613.00	0.	0.
80	7	5	2	4	620.00	0.	600.00	600.00	627.10	0.	0.	614.00	0.	0.
80	7	6	2	4	620.00	0.	600.00	600.00	627.10	0.	1.00	615.00	0.	0.
80	7	7	2	4	620.00	0.	600.00	600.00	627.10	0.	2.00	616.00	0.	0.
80	7	8	2	4	620.00	0.	600.00	600.00	627.10	0.	3.00	617.00	0.	0.
80	7	9	2	4	620.00	0.	600.00	600.00	627.10	0.	4.00	618.00	0.	0.
80	7	10	2	4	620.00	0.	600.00	600.00	627.10	0.	5.00	619.00	0.	0.
80	7	11	2	4	620.00	0.	600.00	600.00	627.10	0.	6.00	620.00	0.	0.
80	7	12	2	4	620.00	0.	600.00	600.00	627.10	0.	7.00	621.00	0.	0.
80	7	13	2	4	620.00	0.	600.00	600.00	627.10	0.	8.00	622.00	0.	0.
80	7	14	2	4	620.00	0.	600.00	600.00	627.10	0.	9.00	623.00	0.	0.
80	7	15	2	4	620.00	0.	600.00	600.00	627.10	0.	10.00	624.00	0.	0.
80	7	16	2	4	620.00	0.	600.00	600.00	627.10	0.	11.00	625.00	0.	0.
80	7	17	2	4	620.00	0.	600.00	600.00	627.10	0.	12.00	626.00	0.	0.
80	7	18	2	4	620.00	0.	600.00	600.00	627.10	0.	13.00	627.00	0.	0.
80	7	19	2	4	620.00	0.	600.00	600.00	627.10	0.	14.00	628.00	17.98	17.98
80	7	20	2	4	620.00	0.	600.00	600.00	627.10	0.	15.00	629.00	18.26	18.26
80	7	21	2	4	620.00	0.	600.00	600.00	627.10	0.	16.00	630.00	18.54	18.54
80	7	22	2	4	620.00	0.	600.00	600.00	627.10	0.	17.00	631.00	18.82	18.82
80	7	23	2	4	620.00	0.	600.00	600.00	627.10	0.	18.00	632.00	18.82	18.82
80	7	24	2	4	620.00	0.	600.00	600.00	627.10	0.	19.00	633.00	18.82	18.82
80	7	25	2	4	620.00	0.	600.00	600.00	627.10	0.	20.00	634.00	18.82	18.82
80	7	26	2	4	620.00	0.	600.00	600.00	627.10	0.	21.00	635.00	18.82	18.82
80	7	27	2	4	620.00	0.	600.00	600.00	627.10	0.	22.00	636.00	18.82	18.82
80	7	28	2	4	620.00	0.	600.00	600.00	627.10	0.	23.00	637.00	18.82	18.82
80	7	29	2	4	620.00	0.	600.00	600.00	627.10	0.	24.00	638.00	18.82	18.82
80	7	30	2	4	620.00	0.	600.00	600.00	627.10	0.	25.00	639.00	18.82	18.82
80	7	31	2	4	620.00	0.	600.00	600.00	627.10	0.	26.00	640.00	18.82	18.82
80	8	22	2	4	620.00	0.	620.00	620.00	627.10	0.	-3.00	631.00	0.	18.82
80	8	23	2	4	620.00	0.	620.00	620.00	627.10	0.	-2.00	632.00	.28	19.10
80	8	24	2	4	620.00	0.	620.00	620.00	627.10	0.	-1.00	633.00	.56	19.38
80	8	25	2	4	620.00	0.	620.00	620.00	627.10	0.	0.	634.00	2.69	21.50
80	8	26	2	4	620.00	0.	620.00	620.00	627.10	0.	1.00	635.00	5.60	24.42
80	8	27	2	4	620.00	0.	620.00	620.00	627.10	0.	2.00	636.00	9.07	27.89
80	8	28	2	4	620.00	0.	620.00	620.00	627.10	0.	3.00	637.00	11.59	30.41
80	8	29	2	4	620.00	0.	620.00	620.00	627.10	0.	4.00	638.00	12.66	31.47
80	8	30	2	4	620.00	0.	620.00	620.00	627.10	0.	5.00	639.00	13.83	32.65
80	8	31	2	4	620.00	0.	620.00	620.00	627.10	0.	6.00	640.00	14.56	33.38

DAMAGE REACH 1 HAS 16. CELLS THAT WERE FLOOD PROOFED TO SPECIFIED LEVELS
DAMAGE REACH 3 HAS 4. CELLS THAT WERE FLOOD PROOFED TO SPECIFIED LEVELS

DAMAGE REACH 3 HAS 12. CELLS WITH DAMAGES STARTING BELOW THE STARTING AGGREGATION ELEVATION

DAMAGE REACH 1 HAS 160. CELLS WITH DAMAGES STARTING ABOVE THE HIGHEST AGGREGATION ELEVTION
DAMAGE REACH 3 HAS 137. CELLS WITH DAMAGES STARTING ABOVE THE HIGHEST AGGREGATION ELEVTION

SAMPLE PROBLEM
FLOOD PROOFING NEW DEVELOPMENT TO THE EXISTING
100-YEAR FLOOD LEVEL
DAMAGE REACH NO. 1

EXHIBIT 4-4
JANUARY 1979

DAMAGE REACH 1-OCONEE TO CONFLUENCE

LAND USE CATEGORIES

WATER SURFACE ELEVATION	1	2	3	4	5	6	7	8	9	10	TOTAL
610.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
611.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
612.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
613.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
614.0	.15	0.	0.	0.	0.	0.	0.	0.	0.	0.	.15
615.0	.15	0.	0.	0.	0.	0.	0.	0.	.07	0.	.22
616.0	.15	0.	0.	0.	0.	0.	0.	0.	.10	0.	.25
617.0	.20	0.	0.	0.	0.	0.	0.	0.	.12	0.	.32
618.0	.25	0.	0.	0.	0.	0.	0.	0.	.15	0.	.40
619.0	.25	0.	0.	0.	0.	0.	0.	0.	.18	0.	.43
620.0	.35	0.	0.	0.	0.	0.	0.	0.	.25	0.	.60
621.0	.40	0.	0.	0.	0.	0.	0.	0.	.27	0.	.67
622.0	.45	0.	0.	0.	0.	0.	0.	0.	.29	0.	.74
623.0	.45	0.	0.	0.	0.	0.	0.	0.	.31	0.	.76
624.0	.55	.30	0.	0.	0.	0.	0.	0.	.33	0.	1.18
625.0	.55	.30	0.	0.	0.	0.	0.	0.	.39	0.	1.24
626.0	.55	.30	0.	0.	0.	0.	0.	0.	.41	0.	1.26
627.0	.70	.30	0.	0.	0.	0.	0.	0.	.43	0.	1.43
627.1	.70	.40	0.	0.	0.	0.	0.	0.	.43	0.	1.53
628.0	.80	.40	0.	17.98	0.	0.	1994.79	0.	.46	0.	2014.43
629.0	.90	.40	0.	18.26	0.	0.	2013.36	6.40	.49	0.	2039.80
630.0	1.10	.40	0.	18.54	0.	0.	2024.57	19.46	.52	0.	2064.58
631.0	1.15	.40	0.	18.82	0.	0.	2024.92	32.51	.55	0.	2078.35

632.0	1.15	.40	0.	19.10	0.	0.	2025.75	45.97	.58	0.	2092.54
633.0	1.25	.40	0.	19.38	0.	0.	2026.93	58.62	.64	0.	2107.22
634.0	1.80	1.00	0.	21.50	0.	0.	2027.28	71.68	.71	0.	2123.97
635.0	1.80	1.00	0.	24.42	0.	0.	2027.28	216.32	.89	0.	2271.71
636.0	1.80	1.00	0.	27.89	0.	0.	2027.28	335.36	.95	0.	2394.28
637.0	1.80	1.00	0.	30.41	0.	0.	2027.28	426.24	1.04	0.	2487.77
638.0	1.80	1.00	0.	31.47	0.	0.	2027.28	472.32	1.13	0.	2535.00
639.0	1.85	1.00	0.	32.65	0.	0.	2027.28	509.13	1.21	0.	2573.12
640.0	1.90	1.00	0.	33.38	0.	0.	2027.28	561.25	1.28	0.	2606.10
616.7 (2 YEAR)	.20	0.	0.	0.	0.	0.	0.	0.	.12	0.	.32
623.5 (10 YEAR)	.45	.10	0.	0.	0.	0.	0.	0.	.32	0.	.87
624.0 (20 YEAR)	.55	.30	0.	0.	0.	0.	0.	0.	.33	0.	1.18
625.6 (50 YEAR)	.55	.30	0.	0.	0.	0.	0.	0.	.40	0.	1.25
627.1 (100 YEAR)	.70	.40	0.	0.	0.	0.	0.	0.	.43	0.	1.53

DAMAGE CATEGORY	LAND USE CODE	LAND USE
1	1	NATURAL VEGETATION
2	2	DEVELOPED OPEN SPACE
3	3	LOW DENSITY HOUSING
4	4	MEDIUM DENSITY HOUSING
5	5	HIGH DENSITY HOUSING
6	6	AGRICULTURE
7	7	INDUSTRIAL
8	8	COMMERCIAL
9	9	PASTURE
10	10	WATER BODIES

SAMPLE PROBLEM
FLOOD PROOFING NEW DEVELOPMENT TO THE EXISTING
100-YEAR FLOOD LEVEL
DAMAGE REACH NO. 3

EXHIBIT 4-4
JANUARY 1979

DAMAGE REACH 3-LAST SECTION OF WEST FORK

LAND USE CATEGORIES

WATER SURFACE ELEVATION	1	2	3	4	5	6	7	8	9	10	TOTAL
695.0	.60	0.	0.	0.	0.	0.	0.	0.	0.	0.	.60
696.0	.70	0.	0.	0.	0.	0.	0.	0.	0.	0.	.70
697.0	.75	0.	0.	0.	0.	0.	0.	0.	0.	0.	.75
698.0	.75	0.	0.	0.	0.	0.	0.	0.	0.	0.	.75
699.0	.80	0.	0.	0.	0.	0.	0.	0.	0.	0.	.80
700.0	.85	0.	0.	0.	0.	0.	0.	0.	0.	0.	.85
701.0	.90	0.	0.	0.	0.	0.	0.	0.	0.	0.	.90
702.0	.95	0.	0.	0.	0.	0.	0.	0.	0.	0.	.95
703.0	1.00	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.00
704.0	1.05	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.05
705.0	1.05	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.05
706.0	1.15	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.15
707.0	1.25	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.25
708.0	1.35	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.35
709.0	1.45	0.	0.	0.	0.	0.	0.	0.	.00	0.	1.45
710.0	1.60	0.	0.	0.	0.	0.	0.	0.	.02	0.	1.62
711.0	1.95	0.	0.	0.	0.	.01	0.	0.	.03	0.	1.99
711.9	2.10	0.	0.	0.	0.	.04	0.	0.	.06	0.	2.19
712.0	2.10	0.	0.	0.	134.10	.04	0.	0.	.06	0.	136.30
713.0	2.30	0.	0.	0.	176.64	.05	0.	0.	.07	0.	179.06
714.0	2.80	0.	0.	0.	207.24	.06	0.	0.	.09	0.	210.19
715.0	3.20	0.	0.	0.	223.32	.15	0.	0.	.15	0.	226.82
716.0	3.55	0.	0.	0.	290.64	.24	0.	0.	.19	0.	294.62

717.0	3.70	0.	0.	0.	357.72	.29	0.	0.	.23	0.	361.94
718.0	5.60	0.	0.	0.	405.42	.33	0.	0.	.27	0.	409.82
719.0	4.00	0.	0.	0.	474.00	.36	0.	0.	.33	0.	478.70
720.0	4.15	0.	0.	0.	532.80	.39	0.	0.	.42	0.	537.76
721.0	4.20	0.	0.	0.	584.46	.41	0.	0.	.47	0.	589.54
722.0	4.25	0.	0.	0.	620.28	.41	0.	0.	.54	0.	625.48
723.0	4.60	0.	0.	0.	648.96	.41	0.	0.	.59	0.	654.56
724.0	4.75	0.	0.	0.	725.04	.45	0.	0.	.65	0.	730.89
725.0	5.10	0.	0.	0.	849.48	.50	0.	0.	.75	0.	855.82
708.6 (2 YEAR)	1.40	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.40
710.2 (10 YEAR)	1.60	0.	0.	0.	0.	0.	0.	0.	.02	0.	1.62
710.8 (20 YEAR)	1.95	0.	0.	0.	0.	0.	0.	0.	.03	0.	1.98
711.5 (50 YEAR)	2.05	0.	0.	0.	0.	.03	0.	0.	.05	0.	2.12
711.9 (100 YEAR)	2.10	0.	0.	0.	0.	.04	0.	0.	.06	0.	2.19

DAMAGE CATEGORY	LAND USE CODE	LAND USE
1	1	NATURAL VEGETATION
2	2	DEVELOPED OPEN SPACE
3	3	LOW DENSITY HOUSING
4	4	MEDIUM DENSITY HOUSING
5	5	HIGH DENSITY HOUSING
6	6	AGRICULTURE
7	7	INDUSTRIAL
8	8	COMMERCIAL
9	9	PASTURE
10	10	WATER BODIES

EXHIBIT 4-5

SAMPLE PROBLEM

REGULATING NEW DEVELOPMENT SUCH THAT THE ZERO STAGE IS PLACED ABOVE THE EXISTING 100-YEAR FLOOD PLAIN

SAMPLE PROBLEM

REGULATING NEW DEVELOPMENT SUCH THAT THE ZERO STAGE IS PLACED ABOVE THE EXISTING 100-YEAR FLOOD PLAIN

Problem Statement

Assess the effect from implementation of a development policy that would require new residential housing, commercial and industrial land uses to be elevated such that zero stages are placed above the existing 100-year flood plain. (In this case the 100-year flood level for the existing or base land use pattern is assumed to be the same as the 100-year level for the 1990 land use pattern. If possible, the user should estimate flood levels for future conditions and input those levels when analyzing future alternatives). Request trace output for the medium density residential land use category in damage reach 1 and obtain damage values for the 2-year, 10-year, 20-year, 50-year and 100-year flood events. (Table 1 is a listing of the data base file used in the Trail Creek Watershed).

Description of Input Requirements

The key input data necessary for assessment of the above conditions are IPOL (J1.1) and the J4 card. The J8 card must be included to provide trace output. The policy water surface elevation is input on the DR cards and should correspond to the 100-year flood event level specified on the SE card.

The completed coding sheets have been included in this sample problem.

Discussion of Results

The trace information provides the user with a check of the computational procedure. In this case the first grid cell displayed reveals that the zero stage of land use 4 has been raised to an elevation of 627.1 feet (which

represents the 100-year flood level at the index location) as indicated by the values shown under the columns labeled "Damage Func. Stage" and "Damage Elev."

The note printed below the trace information indicates the total number of grid cells in damage reaches 1 and 3 that were raised to comply with the stated policy control.

In order to determine the impact of the above policy control the user should compare the damage values of the aggregated damage tables of Exhibits 4-2 and 4-5 (essentially the without and with conditions respectively).

TABLE 1

DATA BASE FILE DIRECTORY

FOR

THE TRAIL CREEK WATERSHED

Data Variable Code	Data Category Code	Identifying Title
1		GRID CELL ROW
	1	Row 1
	2-92	Rows 2-92
2		GRID CELL COLUMN
	1	Column 1
	2-129	Columns 2-129
3		WATERSHED
	1	Trail Creek
5		DAMAGE REACH
	1	Damage reach 1
	2-5	Damage reaches 2-5
10		EXISTING LAND USE
	1	Natural vegetation
	2	Developed open space
	3	Low density residential
	4	Medium density residential
	5	High density residential
	6	Agricultural
	7	Industrial
	8	Commercial
	9	Pasture
	10	Water bodies
11		1990 ALTERNATIVE LAND USE PATTERN
	1	Natural vegetation
	2	Developed open space
	3	Low density residential
	4	Medium density residential
	5	High density residential
	6	Agricultural
	7	Industrial
	8	Commercial
	9	Pasture
	10	Water bodies

TABLE 1 (continued)

DATA BASE FILE DIRECTORY

FOR

THE TRAIL CREEK WATERSHED

Data Variable Code	Data Category Code	Identifying Title
13		REFERENCE FLOOD ELEVATION Flood elevations to the nearest .1 foot are stored for each grid cell in the flood plain
14		TOPOGRAPHIC ELEVATION Land elevations to the nearest .1 foot are stored for each grid cell in the study area

GENERAL PURPOSE DATA FORM
(8 COLUMN FIELDS)

PROGRAM: DAMCAL - EXHIBIT 4-5 DATE: January 1979
REQUESTED BY: D. Gundlach PREPARED BY: CHECKED BY: PAGE: 1 of 4

	1	2	3	4	5	6	7	8	9	10
T1		SAMPLE PROBLEM							EXHIBIT 4-5	
T2		REGULATING NEW DEVELOPMENT SUCH THAT THE ZERO STAGE IS								
T3		PLACED ABOVE THE EXISTING 100-YEAR FLOOD PLAIN							JANUARY 1979	
J1	0.	0.	0.	0.	0.	1.	0.	5.	0.	
J2	2.	1.	18.	93.	129.	0.				
J3	5.	2.	11.	10.	10.	15.	13.	31.		
J4	3.	7.	5.	7.	8.					
JB	1.	7.								
FT(2F7.0,2F8.2,2F7.0,2F2.0)										
ST2 YEAR 10 YEAR 20 YEAR 50 YEAR100 YEAR										
LU	1.	0.	1.	0.	0.	0.	1.00	3.		
LT	1.	NATURAL VEGETATION								
DF	-.01	0.	10.							
DD	0.	.05	.05							
LU	2.	1.	1.	0.	0.	100.	1.00	3.		
LT	2.	DEVELOPED OPEN SPACE								
DF	-.01	0.	10.							
DS	0.	0.	0.							
DC	0.	0.	0.							
DA	0.	100.	100.							
LU	3.	1.	1.0	25000.	7500.	-.	.60	16.		
LT	3.	LOW DENSITY HOUSING								
DF	-2.01	-2.	-1.	0.	1.	2.	3.	4.	5.	6.
DF	7.	8.	9.	10.	11.	12.				
DS	0.	1.	4.	10.	13.	20.	27.	30.	33.	35.
DS	36.	40.	41.	41.	35.	45.				
DC	0.	0.	0.	2.	33.	57.	66.	73.	77.	80.
DC	81.	81.	81.	81.	81.	81.				
DA	0.	5.	5.	5.	5.	5.	5.	5.	5.	5.

GENERAL PURPOSE DATA FORM

(8 COLUMN FIELDS)

PROGRAM: DAMCAL - EXHIBIT 4-5

DATE: January 1979

REQUESTED BY: D. Gundlach

PREPARED BY:

CHECKED BY:

PAGE: 2 of 4

	1	2	3	4	5	6	7	8	9	10
DD	5.	5.	5.	5.	5.	5.				
LD	4.	1.	4.	1000.	-.30	-.	.70	.24		
LT	4.	MEDIUM DENSITY HOUSING								
DE	-2.01	-2.	-1.	0.	1.	2.	3.	4.	5.	6.
DE	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
DE	17.	18.	19.	20.						
DS	0.	1.	2.	9.	11.	18.	24.	26.	29.	31.
DS	32.	35.	36.	36.	40.	40.	41.	42.	43.	44.
DS	45.	45.	45.	45.						
DC	0.	0.	0.	2.	30.	48.	58.	67.	68.	70.
DC	71.	71.	73.	74.	74.	79.	79.	79.	79.	79.
DC	79.	79.	79.	79.						
DD	0.	5.	5.	5.	5.	5.	5.	5.	5.	4.
DD	4.	4.	4.	4.	3.	3.	3.	3.	3.	2.
DD	2.	2.	2.	2.						
LD	5.	1.	12.	50000.	-.30	-.	1.00	.24		
LT	5.	HIGH DENSITY HOUSING								
DE	-5.01	-5.	-4.	-3.	-2.	-1.	0.	1.	2.	3.
DE	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
DE	14.	15.	16.	17.						
DS	0.	2.	2.	2.	2.	2.	2.	9.	13.	17.
DS	20.	21.	23.	24.	26.	33.	37.	41.	43.	45.
DS	46.	48.	50.	50.						
DC	0.	2.	2.	3.	3.	3.	3.	25.	37.	42.
DC	46.	47.	46.	48.	48.	52.	62.	67.	71.	72.
DC	75.	75.	75.	75.						
DD	0.	5.	5.	5.	5.	5.	5.	5.	5.	5.
DD	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
DD	5.	5.	5.	5.						
LU	6.	1.	1.	120.	0.	-.	1.00	10.		

GENERAL PURPOSE DATA FORM
(8 COLUMN FIELDS)

PROGRAM: DAMCAL - EXHIBIT 4-5 DATE: January 1979
REQUESTED BY: P. Gundlach PREPARED BY: CHECKED BY: PAGE 3 of 7

1	2	3	4	5	6	7	8	9	10
LT 6.		AGRICULTURE							
DF 0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
DS 0.	30.5	48	58	59.5	61.5	62.5	62.5	62.5	62.5
DC 0.	0.	0.	0.	0.	0.	0.	0.	0.	0
DA 0.	.5	.5	.5	.5	.5	.5	.5	.5	.5
LU 7.	1.	.2	590000	885000	250000	1.00	.20		
LT 7.		INDUSTRIAL							
DF -2.01	-2.	-1.	0.	1.	2.	3.	4.	5.	6
DF 7.	8.	9.	10.	11.	12.	13.	14.	15.	16
DS 0.	1.	1.	7.	12.	18.	24.	27.	29.	31
DS 32.	35.	38.	40.	44.	44.	45.	45.	46.	47
DC 0.	0.	0.	5.	28.	37.	43.	49.	55.	57
DC 63.	68.	71.	75.	81.	85.	85.	85.	85.	85
DA 0.	0.	0.	5.	15.	20.	22.	30.	35.	50
DA 55.	80.	85.	90.	95.	95.	95.	95.	95.	95
LU 8.	1.	.8	50000	-.60	-	.80	.15		
LT 8.		COMMERCIAL							
DF -5.01	-5.	0.	1.	2.	3.	4.	5.	6.	7
DF 8.	9.	10.	11.	12.					
DS 0.	1.	10.	14.	20.	27.	30.	33.	35.	36
DS 40.	41.	41.	45.	45.					
DC 0.	0.	2.	23.	54.	66.	73.	77.	80.	81
DC 81.	81.	81.	81.	81.					
DA 0.	.5	.5	.5	.5	.5	.5	.5	.5	.5
DA .5	.5	.5	.5	.5					
LU 9.	1.	1.	120	0	-	1.00	.8		
LT 9.		PASTURE							
DF 0.	1.	2.	3.	4.	5.	6.	7.		
DS 0.	9.	10.	12.	13.	14.	18.	18.		
DC 0.	0.	0.	0.	0.	0.	0.	0.		

GENERAL PURPOSE DATA FORM
(7 COLUMN FIELDS)

PROGRAM DAMCAL - EXHIBIT 4-5 DATE January 1979
REQUESTED BY D. Gundlach PREPARED BY CHECKED BY PAGE 1 of 1

	1	2	3	4	5	6	7	8	9	10
[illegible]	0.	5.	5.	5.	5.	5.	5.	5.		
LV	10.	1.	1.	0.	0.	0.	1.00	2.		
LT	10.	WATER BODIES								
DF	0.	10.								
DS	0.	0.								
DC	0.	0.								
DA	0.	0.								
DR	1.	634	627.1			610	1.	0.	0.	
DT	DAMAGE REACH 1-OCONEE TO CONFLUENCE									
SE	616.7	623.5	624.0	625.6	627.1					
DR	3.	714	711.9			695	1.	0.	0.	
DT	DAMAGE REACH 3-LAST SECTION OF WEST FORK									
SE	708.6	710.2	710.8	711.5	711.9					
END										

```
                                                  SAMPLE PROBLEM                                        EXHIBIT 4-5
                                                  REGULATING NEW DEVELOPMENT SUCH THAT THE ZERO STAGE IS
                                                  PLACED ABOVE THE EXISTING 100-YEAR FLOOD PLAIN   JANUARY 1979


                         J1 CARD
                         -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
    J1      2       0       0       0       0       1       0       5       0
                         IPOL     =     2, SPECIFIED NEW DEVELOPMENT WILL HAVE THEIR GROUND FLOOR
                                           PLACED ABOVE A POLICY LEVEL

                         IPROF    =     0, THERE IS NO FLOOD PROOFING IN THIS RUN

                         IEVAC    =     0, THERE IS NO PERMANENT EVACUATION IN THIS RUN

                         IEVCLU   =     0, THERE IS NO PERMANENT EVACUATION IN THIS RUN

                         IPRNT    =     0, NORMAL PRINTOUT

                         ITRACE   =     1, TRACE OUTPUT REQUESTED

                         IAUTO    =     0, NO FILE CREATED FOR ATUDTA PROGRAM

                         ITYPE    =     5, NUMBER OF SINGLE EVENT DAMAGES TO BE CALCULATED

                         IAG      =     0, NO AGGREGATION OF SINGLE EVENT DAMAGES


                         J2 CARD
                         -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
    J2      1       1      10      92     129       0

                         DATA BANK INFORMATION
                         ---------------------

                         NFILE    =      1, THE DATA BANK IS ON THIS COMPUTER UNIT

                         NFORM    =      1, THE DATA BANK IS FORMATTED

                         NDV      =     10, THE NUMBER OF DATA VARIABLES

                         IROW     =     92, THE NUMBER OF ROWS IN THE DATA BANK

                         ICOL     =    129, THE NUMBER OF COLUMNS IN THE DATA BANK

                         IMAGE    =      0, NO PRINTED IMAGE OF INPUT DECK
```

```
                         J3 CARD
                         -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
    J3      5       2       11       10       10       14       13       31

                         DATA VARIABLE INFORMATION
                         -------------------------

                         IDAMRC  =     5, THE DATA VARIABLE THAT IS THE DAMAGE REACH CODE

                         NUDR    =     2, THE NUMBER OF DAMAGE REACHES IN THIS ANALYSIS

                         ILAND   =    11, THE DATA VARIABLE THAT IS THE LAND USE ANALYZED

                         IBASE   =    10, THE DATA VARIABLE CONSIDERED THE BASE CONDITION

                         NOLUC   =    10, THE NUMBER OF LAND USE CATEGORIES

                         ITOPO   =    14, THE DATA VARIABLE THAT IS TOPOGRAPHY

                         IRFPD   =    13, THE DATA VARIABLE THAT IS THE REFERENCE FLOOD ELEVATION

                         IELV    =    31, THE NUMBER OF ELEVATION-DAMAGE POINTS TO BE CALCULATED


                                              THE FOLLOWING LAND USE CATEGORIES
                         J4 CARD(S)           ARE SUBJECT TO POLICY CONTROLS
                         ----------           ------------------------------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
    J4      3       4        5        7       8


                         J8 CARD
                         -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
    J8      1       4

                         TRACE INFORMATION
                         -----------------

                         NUDR    =      1, TRACE OUTPUT PROVIDED IN THIS DAMAGE REACH

                         NOLU    =      4, TRACE OUTPUT PROVIDED FOR THIS LAND USE CATEGORY



                         FORMAT CARD
                         -----------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
    FT(12F4.0,2F4.2,2F4.0,2F2.0)
```

Exhibit 4-5
10 of 19

Several pages of printout deleted relating to the stage-damage functions for particular land use categories (stage-damage functions are identical to those shown in Exhibit 4-2 for the ten land use categories)

SAMPLE PROBLEM EXHIBIT 4-5
REGULATING NEW DEVELOPMENT SUCH THAT THE ZERO STAGE IS
PLACED ABOVE THE EXISTING 100-YEAR FLOOD PLAIN JANUARY 1979

LAND USE CATEGORY NO. 4

MEDIUM DENSITY HOUSING

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-2.01	0.	0.	0.	0.
-2.00	1.00	0.	5.00	.28
-1.00	2.00	0.	5.00	.56
0.	9.00	2.00	5.00	2.69
1.00	11.00	30.00	5.00	5.60
2.00	18.00	48.00	5.00	9.07
3.00	24.00	58.00	5.00	11.59
4.00	26.00	64.00	5.00	12.66
5.00	29.00	68.00	5.00	13.83
6.00	31.00	70.00	4.00	14.36
7.00	32.00	71.00	4.00	14.92
8.00	35.00	71.00	4.00	15.76
9.00	36.00	73.00	4.00	16.21
10.00	36.00	74.00	4.00	16.30
11.00	40.00	74.00	3.00	17.42
12.00	40.00	74.00	3.00	17.42
13.00	41.00	74.00	3.00	17.70
14.00	42.00	74.00	3.00	17.98
15.00	43.00	74.00	3.00	18.26
16.00	44.00	74.00	2.00	18.54
17.00	45.00	74.00	2.00	18.82
18.00	45.00	74.00	2.00	18.82
19.00	45.00	74.00	2.00	18.82
20.00	45.00	74.00	2.00	18.82

DENSITY OF THE LAND USE UNITS PER GRID CELL = 4.00

BASE VALUE OF THE STRUCTURE = 10000.00

BASE VALUE OF THE CONTENTS (30.00 PERCENT OF THE STRUCTURE VALUE) = 3000.00

BASE VALUE OF OTHER = -0.

VACANCY FACTOR (PERCENT DEVELOPED) = 70.0

ONLY NEW DEVELOPMENT WITH THIS LAND USE WILL BE RAISED SO THE GROUND FLOOR IS ABOVE A SPECIFIED LEVEL

Several pages of printout deleted relating to the stage-damage functions for particular land use categories (stage-damage functions are identical to those shown in Exhibit 4-2 for the ten land use categories)

SAMPLE PROBLEM EXHIBIT 4-5
REGULATING NEW DEVELOPMENT SUCH THAT THE ZERO STAGE IS
PLACED ABOVE THE EXISTING 100-YEAR FLOOD PLAIN JANUARY 1979

DAMAGE REACH INDEX LOCATION SUMMARY

ID. NO.	REFERENCE FLOOD ELEVATION	POLICY FLOOD ELEVATION	FLOOD PROOFING ELEVATION	EVACUATION ELEVATION	STARTING DAMAGE ELEVATION	DAMAGE ELEVATION INCREMENT	AGGREGATED DAMAGE RCH. ID.	MODIFY LAND USE DENSITY
1.	634.0	627.1	0.	0.	610.0	1.00	0	0
3.	714.0	711.9	0.	0.	695.0	1.00	0	0

SINGLE EVENTS FOR DAMAGE REACHES

DAMAGE REACH NO.	2 YEAR EVENT	10 YEAR EVENT	20 YEAR EVENT	50 YEAR EVENT	100 YEAR EVENT
1.	616.7	623.5	624.0	625.6	627.1
3.	708.6	710.2	710.8	711.5	711.9

DAMAGE REACH 1 IS BEING TRACED FOR LAND USE 4

* INDICATES ELEVATION IS AT GRID CELL

ROW	COL	ARRAY INDEX	BASE L.U.	ALT. L.U.	*REF. FLOOD ELEV.	* POLICY ELEV.	*TOPO BEFORE POLICY	*TOPO AFTER POLICY	FLOOD PROOF ELEV.	* EVAC. ELEV.	DAMAGE FUNCT. STAGE	DAMAGE ELEV.	DAMAGE	ACCUM. DAMAGE
80	7	16	2	4	620.00	613.10	600.00	613.10	0.	0.	-2.10	625.00	0.	0.
80	7	17	2	4	620.00	613.10	600.00	613.10	0.	0.	-1.10	626.00	.53	.53
80	7	18	2	4	620.00	613.10	600.00	613.10	0.	0.	-.10	627.00	2.48	2.48
80	7	19	2	4	620.00	613.10	600.00	613.10	0.	0.	.90	628.00	5.31	5.31
80	7	20	2	4	620.00	613.10	600.00	613.10	0.	0.	1.90	629.00	8.72	8.72
80	7	21	2	4	620.00	613.10	600.00	613.10	0.	0.	2.90	630.00	11.34	11.34
80	7	22	2	4	620.00	613.10	600.00	613.10	0.	0.	3.90	631.00	12.55	12.55
80	7	23	2	4	620.00	613.10	600.00	613.10	0.	0.	4.90	632.00	13.71	13.71
80	7	24	2	4	620.00	613.10	600.00	613.10	0.	0.	5.90	633.00	14.49	14.49
80	7	25	2	4	620.00	613.10	600.00	613.10	0.	0.	6.90	634.00	14.89	14.89
80	7	26	2	4	620.00	613.10	600.00	613.10	0.	0.	7.90	635.00	15.68	15.68
80	7	27	2	4	620.00	613.10	600.00	613.10	0.	0.	8.90	636.00	16.17	16.17
80	7	28	2	4	620.00	613.10	600.00	613.10	0.	0.	9.90	637.00	16.29	16.29
80	7	29	2	4	620.00	613.10	600.00	613.10	0.	0.	10.90	638.00	17.30	17.30
80	7	30	2	4	620.00	613.10	600.00	613.10	0.	0.	11.90	639.00	17.42	17.42
80	7	31	2	4	620.00	613.10	600.00	613.10	0.	0.	12.90	640.00	17.67	17.67
80	6	22	2	4	620.00	613.10	620.00	620.00	0.	0.	-3.00	631.00	0.	12.55
80	8	23	2	4	620.00	613.10	620.00	620.00	0.	0.	-2.00	632.00	.28	13.99
80	8	24	2	4	620.00	613.10	620.00	620.00	0.	0.	-1.00	633.00	.56	15.05
80	8	25	2	4	620.00	613.10	620.00	620.00	0.	0.	0.	634.00	2.69	17.58
80	8	26	2	4	620.00	613.10	620.00	620.00	0.	0.	1.00	635.00	3.60	21.28
80	8	27	2	4	620.00	613.10	620.00	620.00	0.	0.	2.00	636.00	9.07	25.24
80	8	28	2	4	620.00	613.10	620.00	620.00	0.	0.	3.00	637.00	11.59	27.88
80	8	29	2	4	620.00	613.10	620.00	620.00	0.	0.	4.00	638.00	12.66	29.96
80	8	30	2	4	620.00	613.10	620.00	620.00	0.	0.	5.00	639.00	13.83	31.29
80	8	31	2	4	620.00	613.10	620.00	620.00	0.	0.	6.00	640.00	14.56	32.23

DAMAGE REACH 1 HAS 9. CELLS THAT WERE RAISED TO COMPLY WITH POLICY CONTROLS
DAMAGE REACH 3 HAS 1. CELLS THAT WERE RAISED TO COMPLY WITH POLICY CONTROLS

DAMAGE REACH 3 HAS 12. CELLS WITH DAMAGES STARTING BELOW THE STARTING AGGREGATION ELEVATION

DAMAGE REACH 1 HAS 160. CELLS WITH DAMAGES STARTING ABOVE THE HIGHEST AGGREGATION ELEVTION
DAMAGE REACH 3 HAS 137. CELLS WITH DAMAGES STARTING ABOVE THE HIGHEST AGGREGATION ELEVTION

SAMPLE PROBLEM EXHIBIT 4-5
REGULATING NEW DEVELOPMENT SUCH THAT THE ZERO STAGE IS
PLACED ABOVE THE EXISTING 100-YEAR FLOOD PLAIN JANUARY 1979
DAMAGE REACH NO. 1

DAMAGE REACH 1-OCONEE TO CONFLUENCE

LAND USE CATEGORIES

WATER SURFACE ELEVATION	1	2	3	4	5	6	7	8	9	10	TOTAL
610.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
611.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
612.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
613.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
614.0	.15	0.	0.	0.	0.	0.	0.	0.	0.	0.	.15
615.0	.15	0.	0.	0.	0.	0.	0.	0.	.07	0.	.22
616.0	.15	0.	0.	0.	0.	0.	0.	0.	.10	0.	.25
617.0	.20	0.	0.	0.	0.	0.	0.	0.	.12	0.	.32
618.0	.25	0.	0.	0.	0.	0.	0.	0.	.15	0.	.40
619.0	.25	0.	0.	0.	0.	0.	0.	0.	.18	0.	.43
620.0	.35	0.	0.	0.	0.	0.	0.	0.	.25	0.	.60
621.0	.40	0.	0.	0.	0.	0.	0.	0.	.27	0.	.67
622.0	.45	0.	0.	0.	0.	0.	0.	0.	.29	0.	.74
623.0	.45	0.	0.	0.	0.	0.	0.	0.	.31	0.	.76
624.0	.55	.30	0.	0.	0.	0.	0.	0.	.33	0.	1.18
625.0	.55	.30	0.	0.	0.	0.	0.	0.	.39	0.	1.24
626.0	.55	.30	0.	.53	0.	0.	9.44	0.	.41	0.	11.23
627.0	.70	.30	0.	2.48	0.	0.	142.14	0.	.43	0.	146.04
627.1	.70	.40	0.	2.69	0.	0.	156.88	0.	.43	0.	161.10
628.0	.80	.40	0.	5.31	0.	0.	528.47	0.	.46	0.	535.44
629.0	.90	.40	0.	8.72	0.	0.	753.43	6.40	.49	0.	770.34
630.0	1.10	.40	0.	11.34	0.	0.	908.48	19.46	.52	0.	941.30
631.0	1.15	.40	0.	12.55	0.	0.	1054.19	32.51	.55	0.	1101.35

632.0	1,15	,4C	0,	13,99	0,	0,	1216,16	45,57	,56	0,	1277,87
633.0	1,25	,4C	0,	15,05	0,	0,	1318,53	58,62	,64	0,	1394,69
634.0	1,80	1,0C	0,	17,58	0,	0,	1405,55	71,08	,71	0,	1498,32
635.0	1,80	1,0C	0,	21,28	0,	0,	1580,02	216,32	,89	0,	1821,92
636.0	1,80	1,00	0,	25,24	0,	0,	1693,56	335,36	,95	0,	2057,04
637.0	1,90	1,0C	0,	27,88	0,	0,	1790,05	426,24	1,04	0,	2246,01
638.0	1,80	1,0C	0,	29,96	0,	0,	1926,05	472,32	1,13	0,	2430,29
639.0	1,85	1,00	0,	31,25	0,	0,	1993,30	509,13	1,21	0,	2537,76
640.0	1,90	1,0C	0,	32,23	0,	0,	2007,46	541,25	1,28	0,	2585,12
616.7 (2 YEAR)	,20	0,	0,	0,	0,	0,	0,	0,	,12	0,	,32
623.5 (10 YEAR)	,45	,10	0,	0,	0,	0,	0,	0,	,32	0,	,87
624.0 (20 YEAR)	,55	,30	0,	0,	0,	0,	0,	0,	,33	0,	1,18
625.6 (50 YEAR)	,55	,30	0,	,42	0,	0,	9,44	0,	,40	0,	11,11
627.1 (100 YEAR)	,70	,40	0,	2,69	0,	0,	156,88	0,	,43	0,	161,10

DAMAGE CATEGORY	LAND USE CODE	LAND USE
1	1	NATURAL VEGETATION
2	2	DEVELOPED OPEN SPACE
3	3	LOW DENSITY HOUSING
4	4	MEDIUM DENSITY HOUSING
5	5	HIGH DENSITY HOUSING
6	6	AGRICULTURE
7	7	INDUSTRIAL
8	8	COMMERCIAL
9	9	PASTURE
10	10	WATER BODIES

SAMPLE PROBLEM   EXHIBIT 4-5
REGULATING NEW DEVELOPMENT SUCH THAT THE ZERO STAGE IS
PLACED ABOVE THE EXISTING 100-YEAR FLOOD PLAIN   JANUARY 1979
DAMAGE REACH NO. 3

DAMAGE REACH 3-LAST SECTION OF WEST FORK

LAND USE CATEGORIES

WATER SURFACE ELEVATION	1	2	3	4	5	6	7	8	9	10	TOTAL
695.0	.60	0.	0.	0.	0.	0.	0.	0.	0.	0.	.60
696.0	.70	0.	0.	0.	0.	0.	0.	0.	0.	0.	.70
697.0	.75	0.	0.	0.	0.	0.	0.	0.	0.	0.	.75
698.0	.75	0.	0.	0.	0.	0.	0.	0.	0.	0.	.75
699.0	.80	0.	0.	0.	0.	0.	0.	0.	0.	0.	.80
700.0	.85	0.	0.	0.	0.	0.	0.	0.	0.	0.	.85
701.0	.90	0.	0.	0.	0.	0.	0.	0.	0.	0.	.90
702.0	.95	0.	0.	0.	0.	0.	0.	0.	0.	0.	.95
703.0	1.00	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.00
704.0	1.05	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.05
705.0	1.05	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.05
706.0	1.15	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.15
707.0	1.25	0.	0.	0.	15.60	0.	0.	0.	0.	0.	16.85
708.0	1.35	0.	0.	0.	15.78	0.	0.	0.	0.	0.	17.13
709.0	1.45	0.	0.	0.	17.40	0.	0.	0.	.00	0.	18.85
710.0	1.60	0.	0.	0.	17.40	0.	0.	0.	.02	0.	19.02
711.0	1.95	0.	0.	0.	33.00	.01	0.	0.	.03	0.	34.99
711.9	2.10	0.	0.	0.	34.08	.04	0.	0.	.06	0.	36.27
712.0	2.10	0.	0.	0.	42.42	.04	0.	0.	.06	0.	44.62
713.0	2.30	0.	0.	0.	120.96	.05	0.	0.	.07	0.	123.38
714.0	2.80	0.	0.	0.	165.66	.06	0.	0.	.09	0.	168.61
715.0	3.20	0.	0.	0.	200.76	.15	0.	0.	.15	0.	204.26
716.0	3.55	0.	0.	0.	278.10	.24	0.	0.	.19	0.	282.08

717.0	3.70	0.	0.	0.	342.90	.29	0.	0.	.23	0.	347.12
718.0	3.80	0.	0.	0.	395.22	.33	0.	0.	.27	0.	399.62
719.0	4.00	0.	0.	0.	443.52	.36	0.	0.	.33	0.	448.22
720.0	4.15	0.	0.	0.	471.72	.39	0.	0.	.42	0.	476.68
721.0	4.20	0.	0.	0.	533.46	.41	0.	0.	.47	0.	538.54
722.0	4.25	0.	0.	0.	582.90	.41	0.	0.	.54	0.	588.10
723.0	4.60	0.	0.	0.	624.72	.43	0.	0.	.59	0.	630.32
724.0	4.75	0.	0.	0.	706.26	.45	0.	0.	.65	0.	712.11
725.0	5.10	0.	0.	0.	837.66	.50	0.	0.	.75	0.	844.00
708.6 (2 YEAR)	1.40	0.	0.	0.	16.86	0.	0.	0.	0.	0.	18.26
710.2 (10 YEAR)	1.60	0.	0.	0.	17.40	0.	0.	0.	.02	0.	19.02
710.8 (20 YEAR)	1.95	0.	0.	0.	33.00	0.	0.	0.	.03	0.	34.98
711.5 (50 YEAR)	2.05	0.	0.	0.	33.36	.03	0.	0.	.05	0.	35.48
711.9 (100 YEAR)	2.10	0.	0.	0.	34.04	.04	0.	0.	.06	0.	36.27

DAMAGE CATEGORY	LAND USE CODE	LAND USE
1	1	NATURAL VEGETATION
2	2	DEVELOPED OPEN SPACE
3	3	LOW DENSITY HOUSING
4	4	MEDIUM DENSITY HOUSING
5	5	HIGH DENSITY HOUSING
6	6	AGRICULTURE
7	7	INDUSTRIAL
8	8	COMMERCIAL
9	9	PASTURE
10	10	WATER BODIES

EXHIBIT 4-6

SAMPLE PROBLEM

UTILIZING FLOOD PLAIN REGULATION, FLOOD PROOFING AND EVACUATION

SAMPLE PROBLEM

UTILIZING FLOOD PLAIN REGULATION, FLOOD PROOFING AND EVACUATION

Problem Statement

Determine the modified damages that would occur with the implementation of the following:

- a policy control that would elevate the zero stage of new development in residential housing to the 100-year flood event level

- flood proofing of new development in residential housing to the 100-year flood level (target protection level)

- permanent evacuation of new development classified as commercial or industrial from the 20-year flood plain

- and modification of evacuated areas into open-developed land uses.

In addition request trace output for the medium density residential land use category in damage reach 1. (Table 1 is a listing of the data base file used in the Trail Creek Watershed).

Description of Input Requirements

The input value, IPOL (J1.1), designates the general type of policy control and IPROF (J1.2) specifies the type of flood proofing option requested. The evacuation of specified new development is indicated by IEVAC (J1.3) and modification of evacuated land use areas indicated by IEVCLU (J1.4). The J4, J5 and J7 cards define the land use categories to be regulated or protected by policy control, flood proofing and evacuation.

Discussion of Results

Although the stage-damage function for each land use category is not shown in this sample problem, it should be noted that a brief description of the damage reduction measure (s) affecting each land use category is printed at the bottom of the appropriate stage-damage function. As shown by the information printed below the input stage-damage functions for land use categories 4 and 7 (pages 14 and 16), medium density housing is affected by policy control and flood proofing options and industrial is affected by evacuation.

The index location water surface elevations (for the damage reaches analyzed) governing each of the damage reduction options are tabulated in the "Damage Reach Index Location Summary" page 18. The 100-year flood event levels (at the index locations) appear under "Policy Flood Elevation" and "Flood Proofing Elevation" whereas the 20-year flood event levels appear under "Evacuation Elevation" (as input by the user on the DR cards). The regulating flood event levels should be identical to the corresponding levels printed for the single events (page 18 also).

A comparison of the trace information of Exhibits 4-5 and 4-6 provides the user with a check on the computational procedures involved. Since the first grid cell traced in Exhibit 4-5 represents a policy control identical to the one used in this sample problem, the elevation-damage relationships should be the same above the 100-year water surface elevation (627.1 feet). The printed information at the bottom of page 19 indicates the total number of grid cells affected by the damage reduction measures utilized.

An inspection of the aggregated damage tables for damage reaches 1 and 3 should reveal the following:

- grid cells classified as land use categories 3, 4 and 5 (residential housing) should show no damage up through the 100-year flood event elevation at the index location

- since eight grid cells in damage reach 1 were evacuated and modified to developed open space, the aggregated damage values (damage reach 1) under land use 2 should reflect an increase corresponding to additional grid cells up to a maximum of 8 (at an elevation of 640 feet the aggregated damage is $1,800 for land use 2 which is an increase of $800 over the $1,000 shown for the corresponding damage of Exhibit 4-2 . . . . . . this $800 increase represents 8 grid cells of developed open space).

As in the preceding sample problems the user can compare the impact of the various damage reduction options by comparing the aggregated damage values of Exhibits 4-2 and 4-6 (the without and with conditions respectively).

TABLE 1

DATA BASE FILE DIRECTORY
FOR
THE TRAIL CREEK WATERSHED

Data Variable Code	Data Category Code	Identifying Title
1		GRID CELL ROW
	1	Row 1
	2-92	Rows 2-92
2		GRID CELL COLUMN
	1	Column 1
	2-129	Columns 2-129
3		WATERSHED
	1	Trail Creek
5		DAMAGE REACH
	1	Damage reach 1
	2-5	Damage reaches 2-5
10		EXISTING LAND USE
	1	Natural vegetation
	2	Developed open space
	3	Low density residential
	4	Medium density residential
	5	High density residential
	6	Agricultural
	7	Industrial
	8	Commercial
	9	Pasture
	10	Water bodies
11		1990 ALTERNATIVE LAND USE PATTERN
	1	Natural vegetation
	2	Developed open space
	3	Low density residential
	4	Medium density residential
	5	High density residential
	6	Agricultural
	7	Industrial
	8	Commercial
	9	Pasture
	10	Water bodies

TABLE 1 (continued)

DATA BASE FILE DIRECTORY

FOR

THE TRAIL CREEK WATERSHED

Data Variable Code	Data Category Code	Identifying Title
13		REFERENCE FLOOD ELEVATION Flood elevations to the nearest .1 foot are stored for each grid cell in the flood plain
14		TOPOGRAPHIC ELEVATION Land elevations to the nearest .1 foot are stored for each grid cell in the study area

GENERAL PURPOSE DATA FORM
(8 COLUMN FIELDS)

PROGRAM DAMCAL - EXHIBIT 4-6 DATE January 1979

REQUESTED BY D. GUNDLACH PREPARED BY CHECKED BY PAGE 1 of 4

	1	2	3	4	5	6	7	8	9	10
T1			SAMPLE PROBLEM						EXHIBIT 4-6	
T2			UTILIZING FLOOD PLAIN REGULATION, FLOOD PROOFING,							
T3			AND EVACUATION						JANUARY 1979	
J1	2	4	2	2	0	1	0	5	0	
J2	1	1	18	92	129	0				
J3	5	2	11	10	10	14	13	31		
J4	3	8	5							
J5	3	4	5							
J7	7	8								
J8	1	4								
FT(12F4.0,2F8.2,2F4.0,2F2.0)										
ST2 YEAR 10 YEAR 20 YEAR 50 YEAR100 YEAR										
LU	1	0	1	0	0	0	1.00	3		
LT	1		NATURAL VEGETATION							
DE	-.01	0	10							
DD	0	.05	.05							
LU	2	1	1	0	0	100	1.00	3		
LT	2		DEVELOPED OPEN SPACE							
DE	-.01	0	10							
DS	0	0	0							
DC	0	0	0							
DD	0	100	100							
LU	3	1	1.0	25000	7500	-	.60	16		
LT	3		LOW DENSITY HOUSING							
DF	-2.01	-2	-1	0	1	2	3	4	5	6
DF	7	8	9	10	11	12				
DS	0	1	4	10	13	20	27	30	33	35
DS	36	40	41	41	45	45				
DC	0	0	0	2	33	54	66	23	77	80
DC	81	81	81	81	81	81				
DD	0	5	5	5	5	5	5	5	5	5

GENERAL PURPOSE DATA FORM

(8 COLUMN FIELDS)

PROGRAM: DAMCAL - EXHIBIT 4-6 DATE: January 1979

REQUESTED BY: D. Gundlach PREPARED BY: CHECKED BY: PAGE 2 of 4

	1	2	3	4	5	6	7	8	9	10
DD	5.	5.	5.	5.	5.	5.				
LU	4.	1.	4.	10000.	-30.	-.	.70	24.		
LT	4.	MEDIUM DENSITY HOUSING								
DF	-2.01	-2.	-1.	0.	1.	2.	3.	4.	5.	6
DF	7.	8.	9.	10.	11.	12.	13.	14.	15.	16
DF	17.	18.	19.	20.						
DS	0.	1.	2.	9.	11.	18.	24.	26.	29.	31
DS	32.	35.	36.	36.	40.	40.	41.	42.	43.	44
DS	45.	45.	45.	45.						
DC	0.	0.	0.	2.	30.	48.	58.	64.	68.	70
DC	71.	71.	73.	74.	74.	74.	74.	74.	74.	74
DC	74.	74.	74.	74.						
DD	0.	5.	5.	5.	5.	5.	5.	5.	5.	4
DD	4.	4.	4.	4.	3.	3.	3.	3.	3.	2
DD	2.	2.	2.	2.						
LU	5.	1.	12.	50000.	-30.	-.	1.00	24.		
LT	5.	HIGH DENSITY HOUSING								
DF	-5.01	-5.	-4.	-3.	-2.	-1.	0.	1.	2.	3
DF	4.	5.	6.	7.	8.	9.	10.	11.	12.	13
DF	14.	15.	16.	17.						
DS	0.	2.	2.	2.	2.	2.	2.	9.	13.	17
DS	20.	21.	23.	24.	26.	33.	37.	41.	43.	45
DS	46.	48.	50.	50.						
DC	0.	2.	2.	3.	3.	3.	3.	25.	37.	49
DC	46.	47.	48.	48.	48.	52.	62.	67.	71.	74
DC	75.	75.	75.	75.						
DD	0.	5.	5.	5.	5.	5.	5.	5.	5.	5
DD	5.	5.	5.	5.	5.	5.	5.	5.	5.	5
DD	5.	5.	5.	5.						
UU	6.	1.	1.	120.	0.	-.	1.00	10.		

GENERAL PURPOSE DATA FORM
(8 COLUMN FIELDS)

PROGRAM: DAMCAL - EXHIBIT 4-6
REQUESTED BY: D. Gundlach
PREPARED BY:
CHECKED BY:
DATE: January 1979
PAGE: 3 of 4

	1	2	3	4	5	6	7	8	9	10
LT	6	AGRICULTURE								
VL	0	1	2	3	4	5	6	7	8	9
DS	0	30.5	40	48	54.5	61.5	68.5	68.5	68.5	68.5
DC	0	0	0	0	0	0	0	0	0	0
DD	0	5	5	5	5	5	5	5	5	5
LU	7	1	.2	590.000	885000	250000	1.00	20		
LT	7	INDUSTRIAL								
DE	-2.01	-2	-1	0	1	2	3	4	5	6
DE	7	8	9	10	11	12	13	14	15	16
DS	0	1	1	7	12	18	24	27	29	31
DS	32	35	38	40	44	44	45	45	46	47
DC	0	0	0	5	28	37	43	49	55	59
DC	63	67	71	75	81	85	85	85	85	85
DD	0	0	0	5	15	20	22	30	45	50
DD	55	60	85	90	95	95	95	95	95	95
LU	8	1	4	50000	-.60	-	.80	15		
LT	8	COMMERCIAL								
DE	-5.01	-5	0	1	2	3	4	5	6	7
DE	8	9	10	11	12					
DS	0	1	10	14	20	27	30	33	35	36
DS	40	41	41	45	45					
DC	0	0	2	33	54	66	73	77	80	81
DC	81	81	81	81	81					
DD	0	5	5	5	5	5	5	5	5	5
DD	5	5	5	5	5					
LU	9	1	4	120	0	-	1.00	8		
LT	9	PASTURE								
DE	0	1	2	3	4	5	6	7		
DS	0	9	10	12	14	16	18	18		
DC	0	0	0	0	0	0	0	0		

GENERAL PURPOSE DATA FORM

(8 COLUMN FIELDS)

PROGRAM DAMCAL - EXHIBIT 4-6 DATE January 1979

REQUESTED BY D. Gundlach PREPARED BY CHECKED BY PAGE 4 OF 4

1	2	3	4	5	6	7	8	9	10
DØ 0	5	5	5	5	5	5	5		
LV 10	1	1	0	0	0	1.00	2		
LT 10	WATER BØDIES								
DE 0	10								
DS 0	0								
DC 0	0								
DØ 0	0								
DR 1	639	627.1	627.1	624.0	610	1	0	0	
DT DAMAGE REACH 1-OCONEE TO CONFLUENCE									
SE 616.7	623.5	624.0	625.6	627.1					
DR 3	714	711.9	711.9	710.8	695	1	0	0	
DT DAMAGE REACH 3-LAST SECTION OF WEST FORK									
SE 708.6	710.2	710.8	711.5	711.9					
END									

```
                      J1 CARD
                      -------
CC 1234567890123456789012345678901234567890123456789012345678901234567890
    J1      2       4       2       2       0       1       0       5       0
                      IPOL    =     2, SPECIFIED NEW DEVELOPMENT WILL HAVE THEIR GROUND FLOOR
                                       PLACED ABOVE A POLICY LEVEL

                      IPROF   =     4, SPECIFIED NEW DEVELOPMENT WILL BE FLOOD PROOFED TO A SPECIFIED LEVEL

                      IEVAC   =     2, EVACUATE ALL NEW DEVELOPMENT WHICH HAS ITS GROUND LEVEL
                                       IN THE RESTRICTED FLOOD PLAIN

                      IEVCLU  =     2, EVACUATED CELLS WILL BE AGGREGATED INTO THIS LAND USE CATEGORY

                      IPRNT   =     0, NORMAL PRINTOUT

                      ITRACE  =     1, TRACE OUTPUT REQUESTED

                      IAUTO   =     0, NO FILE CREATED FOR ATODTA PROGRAM

                      ITYPE   =     5, NUMBER OF SINGLE EVENT DAMAGES TO BE CALCULATED

                      IAG     =     0, NO AGGREGATION OF SINGLE EVENT DAMAGES


                      J2 CARD
                      -------
CC 1234567890123456789012345678901234567890123456789012345678901234567890
    J2      1       1       18      92      129     0

                      DATA BANK INFORMATION
                      ---------------------

                      NFILE   =     1, THE DATA BANK IS ON THIS COMPUTER UNIT

                      NFORM   =     1, THE DATA BANK IS FORMATTED

                      NDV     =    18, THE NUMBER OF DATA VARIABLES

                      IROW    =    92, THE NUMBER OF ROWS IN THE DATA BANK

                      ICOL    =   129, THE NUMBER OF COLUMNS IN THE DATA BANK

                      IMAGE   =     0, NO PRINTED IMAGE OF INPUT DECK
```

```
                                  J3 CARD
                                  -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J3       5         2        11        10        10        14        13        31

                                  DATA VARIABLE INFORMATION
                                  -------------------------

                                  IDAMRC  =     5, THE DATA VARIABLE THAT IS THE DAMAGE REACH CODE

                                  NODR    =     2, THE NUMBER OF DAMAGE REACHES IN THIS ANALYSIS

                                  ILAND   =    11, THE DATA VARIABLE THAT IS THE LAND USE ANALYZED

                                  IBASE   =    10, THE DATA VARIABLE CONSIDERED THE BASE CONDITION

                                  NOLUC   =    10, THE NUMBER OF LAND USE CATEGORIES

                                  ITOPO   =    14, THE DATA VARIABLE THAT IS TOPOGRAPHY

                                  IRFFD   =    13, THE DATA VARIABLE THAT IS THE REFERENCE FLOOD ELEVATION

                                  I'      =    31, THE NUMBER OF ELEVATION-DAMAGE POINTS TO BE CALCULATED


                                                      THE FOLLOWING LAND USE CATEGORIES
                                  J4 CARD(S)          ARE SUBJECT TO POLICY CONTROLS
                                  ----------          ------------------------------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J4       3         4         5


                                                      THE FOLLOWING LAND USE CATEGORIES WITH NEW
                                  J5 CARD(S)          DEVELOPMENT ARE SUBJECT TO FLOOD PROOFING
                                  ----------          -----------------------------------------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J5       3         4         5


                                                      THE FOLLOWING LAND USE CATEGORIES WITH
                                  J7 CARD(S)          NEW DEVELOPMENT ARE SUBJECT TO EVACUATION
                                  ----------          -----------------------------------------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J7       7         8


                                  J8 CARD
                                  -------
CC 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   J8       1         4
```

```
TRACE INFORMATION
=================

NNDR    =    1, TRACE OUTPUT PROVIDED IN THIS DAMAGE REACH

NNLU    =    4, TRACE OUTPUT PROVIDED FOR THIS LAND USE CATEGORY


         FORMAT CARD
         ===========
CC 1234567890123456789012345678901234567890123456789012345678901234567890123456789O
   FT(12F4.0,2F8.2,2F4.0,2F2.0)
```

Several pages of printout deleted relating to the stage-damage functions for particular land use categories (stage-damage functions are identical to those shown in Exhibit 4-2 for the ten land use categories)

LAND USE CATEGORY NO. 4

MEDIUM DENSITY HOUSING

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-2.01	0.	0.	0.	0.
-2.00	1.00	0.	5.00	.28
-1.00	2.00	0.	5.00	.56
0.	9.00	2.00	5.00	2.69
1.00	11.00	30.00	5.00	5.60
2.00	18.00	48.00	5.00	9.07
3.00	24.00	58.00	5.00	11.59
4.00	26.00	64.00	5.00	12.66
5.00	29.00	68.00	5.00	13.83
6.00	31.00	70.00	4.00	14.56
7.00	32.00	71.00	4.00	14.92
8.00	35.00	71.00	4.00	15.76
9.00	36.00	73.00	4.00	16.21
10.00	36.00	74.00	4.00	16.30
11.00	40.00	74.00	3.00	17.42
12.00	40.00	74.00	3.00	17.42
13.00	41.00	74.00	3.00	17.70
14.00	42.00	74.00	3.00	17.98
15.00	43.00	74.00	3.00	18.26
16.00	44.00	74.00	2.00	18.54
17.00	45.00	74.00	2.00	18.82
18.00	45.00	74.00	2.00	18.82
19.00	45.00	74.00	2.00	18.82
20.00	45.00	74.00	2.00	18.82

DENSITY OF THE LAND USE UNITS PER GRID CELL = 4.00

BASE VALUE OF THE STRUCTURE = 10000.00

BASE VALUE OF THE CONTENTS (30.00 PERCENT OF THE STRUCTURE VALUE) = 3000.00

BASE VALUE OF OTHER = -0.

VACANCY FACTOR (PERCENT DEVELOPED) = 70.0

ONLY NEW DEVELOPMENT WITH THIS LAND USE WILL BE RAISED SO THE GROUND FLOOR IS ABOVE A SPECIFIED LEVEL

ONLY NEW DEVELOPMENT IN THIS LAND USE WILL BE FLOOD PROOFED TO A SPECIFIED PROTECTION LEVEL

Several pages of printout deleted relating to the stage-damage functions for particular land use categories (stage-damage functions are identical to those shown in Exhibit 4-2 for the ten land use categories)

SAMPLE PROBLEM
UTILIZING FLOOD PLAIN REGULATION, FLOOD PROOFING,
AND EVACUATION

EXHIBIT 4-6
JANUARY 1979

LAND USE CATEGORY NO. 7

INDUSTRIAL

DEPTH OF WATER	PERCENT DAMAGE STRUCTURE	PERCENT DAMAGE CONTENTS	PERCENT DAMAGE OTHER	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-2.01	0.	0.	0.	0.
-2.00	1.00	0.	0.	1.18
-1.00	1.00	0.	0.	1.18
0.	7.00	5.00	5.00	19.61
1.00	12.00	28.00	15.00	71.22
2.00	18.00	37.00	20.00	96.73
3.00	24.00	43.00	22.00	115.43
4.00	27.00	49.00	30.00	133.59
5.00	29.00	55.00	45.00	154.07
6.00	31.00	59.00	50.00	166.01
7.00	32.00	63.00	55.00	176.77
8.00	35.00	67.00	80.00	199.89
9.00	38.00	71.00	85.00	213.01
10.00	40.00	75.00	90.00	224.95
11.00	44.00	81.00	95.00	242.79
12.00	44.00	85.00	95.00	249.87
13.00	45.00	85.00	95.00	251.05
14.00	45.00	85.00	95.00	251.05
15.00	46.00	85.00	95.00	252.23
16.00	47.00	85.00	95.00	253.41

DENSITY OF THE LAND USE UNITS PER GRID CELL = .20

BASE VALUE OF THE STRUCTURE =590000.00

BASE VALUE OF THE CONTENTS =885000.00

BASE VALUE OF OTHER =250000.00

VACANCY FACTOR (PERCENT DEVELOPED) =100.0

ALL GRID CELLS WITH NEW DEVELOPMENT AND THIS LAND USE WHICH HAVE THEIR GROUND FLOOR
IN THE RESTRICTED FLOOD PLAIN WILL BE EVACUATED AND THE DAMAGES WILL BE AGGREGATED INTO LAND USE 2

Several pages of printout deleted relating to the stage-damage functions for particular land use categories (stage-damage functions are identical to those shown in Exhibit 4-2 for the ten land use categories)

SAMPLE PROBLEM
UTILIZING FLOOD PLAIN REGULATION, FLOOD PROOFING,
AND EVACUATION

EXHIBIT 4-6

JANUARY 1979

DAMAGE REACH INDEX LOCATION SUMMARY

ID. NO.	REFERENCE FLOOD ELEVATION	POLICY FLOOD ELEVATION	FLOOD PROOFING ELEVATION	EVACUATION ELEVATION	STARTING DAMAGE ELEVATION	DAMAGE ELEVATION INCREMENT	AGGREGATED DAMAGE RCH. ID.	MODIFY LAND USE DENSITY
1.	634.0	627.1	627.1	624.0	610.0	1.00	0	0
3.	714.0	711.9	711.9	710.8	695.0	1.00	0	0

SINGLE EVENTS FOR DAMAGE REACHES

DAMAGE REACH NO.	2 YEAR EVENT	10 YEAR EVENT	20 YEAR EVENT	50 YEAR EVENT	100 YEAR EVENT
1.	616.7	623.5	624.0	625.6	627.1
3.	708.6	710.2	710.8	711.5	711.9

DAMAGE REACH 1 IS BEING TRACED FOR LAND USE 4

* INDICATES ELEVATION IS AT GRID CELL

ROW	COL	ARRAY INDEX	BASE L.U.	ALT. L.U.	*REF. FLOOD ELEV.	* POLICY ELEV.	*TOPO BEFORE POLICY	*TOPO AFTER POLICY	FLOOD PROOF ELEV.	* EVAC. ELEV.	DAMAGE FUNCT. STAGE	DAMAGE ELEV.	DAMAGE	ACCUM. DAMAGE
80	7	16	2	4	620.00	613.10	600.00	613.10	627.10	610.00	-2.10	625.00	0.	0.
80	7	17	2	4	620.00	613.10	600.00	613.10	627.10	610.00	-1.10	626.00	0.	0.
80	7	18	2	4	620.00	613.10	600.00	613.10	627.10	610.00	-.10	627.00	0.	0.
80	7	19	2	4	620.00	613.10	600.00	613.10	627.10	610.00	.90	628.00	5.31	5.31
80	7	20	2	4	620.00	613.10	600.00	613.10	627.10	610.00	1.90	629.00	6.72	6.72
80	7	21	2	4	620.00	613.10	600.00	613.10	627.10	610.00	2.90	630.00	11.34	11.34
80	7	22	2	4	620.00	613.10	600.00	613.10	627.10	610.00	3.90	631.00	12.55	12.55
80	7	23	2	4	620.00	613.10	600.00	613.10	627.10	610.00	4.90	632.00	13.71	13.71
80	7	24	2	4	620.00	613.10	600.00	613.10	627.10	610.00	5.90	633.00	14.49	14.49
80	7	25	2	4	620.00	613.10	600.00	613.10	627.10	610.00	6.90	634.00	14.69	14.69
80	7	26	2	4	620.00	613.10	600.00	613.10	627.10	610.00	7.90	635.00	15.68	15.68
80	7	27	2	4	620.00	613.10	600.00	613.10	627.10	610.00	8.90	636.00	16.17	16.17
80	7	28	2	4	620.00	613.10	600.00	613.10	627.10	610.00	9.90	637.00	16.29	16.29
80	7	29	2	4	620.00	613.10	600.00	613.10	627.10	610.00	10.90	638.00	17.30	17.30
80	7	30	2	4	620.00	613.10	600.00	613.10	627.10	610.00	11.90	639.00	17.42	17.42
80	7	31	2	4	620.00	613.10	600.00	613.10	627.10	610.00	12.90	640.00	17.67	17.67
80	8	22	2	4	620.00	613.10	620.00	620.00	627.10	610.00	-3.00	631.00	0.	12.55
80	8	23	2	4	620.00	613.10	620.00	620.00	627.10	610.00	-2.00	632.00	.28	13.99
80	8	24	2	4	620.00	613.10	620.00	620.00	627.10	610.00	-1.00	633.00	.56	15.05
80	8	25	2	4	620.00	613.10	620.00	620.00	627.10	610.00	0.	634.00	2.69	17.58
80	8	26	2	4	620.00	613.10	620.00	620.00	627.10	610.00	1.00	635.00	5.60	21.28
80	8	27	2	4	620.00	613.10	620.00	620.00	627.10	610.00	2.00	636.00	9.07	25.24
80	8	28	2	4	620.00	613.10	620.00	620.00	627.10	610.00	3.00	637.00	11.59	27.88
80	8	29	2	4	620.00	613.10	620.00	620.00	627.10	610.00	4.00	638.00	12.66	29.96
80	8	30	2	4	620.00	613.10	620.00	620.00	627.10	610.00	5.00	639.00	13.83	31.25
80	8	31	2	4	620.00	613.10	620.00	620.00	627.10	610.00	6.00	640.00	14.56	32.23

DAMAGE REACH 1 HAS 1. CELLS THAT WERE RAISED TO COMPLY WITH POLICY CONTROLS
DAMAGE REACH 3 HAS 1. CELLS THAT WERE RAISED TO COMPLY WITH POLICY CONTROLS

DAMAGE REACH 1 HAS 2. CELLS THAT WERE FLOOD PROOFED TO SPECIFIED LEVELS
DAMAGE REACH 3 HAS 4. CELLS THAT WERE FLOOD PROOFED TO SPECIFIED LEVELS

DAMAGE REACH 1 HAS 8. CELLS THAT WERE EVACUATED

DAMAGE REACH 3 HAS 12. CELLS WITH DAMAGES STARTING BELOW THE STARTING AGGREGATION ELEVATION

DAMAGE REACH 1 HAS 160. CELLS WITH DAMAGES STARTING ABOVE THE HIGHEST AGGREGATION ELEVTION
DAMAGE REACH 3 HAS 137. CELLS WITH DAMAGES STARTING ABOVE THE HIGHEST AGGREGATION ELEVTION

SAMPLE PROBLEM EXHIBIT 4-6
UTILIZING FLOOD PLAIN REGULATION, FLOOD PROOFING,
AND EVACUATION JANUARY 1979
DAMAGE REACH NO. 1

DAMAGE REACH 1-OCONEE TO CONFLUENCE

LAND USE CATEGORIES

WATER SURFACE ELEVATION	1	2	3	4	5	6	7	8	9	10	TOTAL
610.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
611.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
612.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
613.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
614.0	.15	.70	0.	0.	0.	0.	0.	0.	0.	0.	.85
615.0	.15	.70	0.	0.	0.	0.	0.	0.	.07	0.	.92
616.0	.15	.70	0.	0.	0.	0.	0.	0.	.10	0.	.95
617.0	.20	.70	0.	0.	0.	0.	0.	0.	.12	0.	1.02
618.0	.25	.80	0.	0.	0.	0.	0.	0.	.15	0.	1.20
619.0	.25	.80	0.	0.	0.	0.	0.	0.	.18	0.	1.23
620.0	.35	.80	0.	0.	0.	0.	0.	0.	.25	0.	1.40
621.0	.40	.80	0.	0.	0.	0.	0.	0.	.27	0.	1.47
622.0	.45	.80	0.	0.	0.	0.	0.	0.	.29	0.	1.54
623.0	.45	.80	0.	0.	0.	0.	0.	0.	.31	0.	1.56
624.0	.55	1.10	0.	0.	0.	0.	0.	0.	.33	0.	1.98
625.0	.55	1.10	0.	0.	0.	0.	0.	0.	.39	0.	2.04
626.0	.55	1.10	0.	0.	0.	0.	0.	0.	.41	0.	2.06
627.0	.70	1.10	0.	0.	0.	0.	0.	0.	.43	0.	2.23
627.1	.70	1.20	0.	0.	0.	0.	0.	0.	.43	0.	2.33
628.0	.80	1.20	0.	5. 1	0.	0.	0.	0.	.46	0.	7.77
629.0	.90	1.20	0.	8.72	0.	0.	0.	6.40	.49	0.	17.71
630.0	1.10	1.20	0.	11.34	0.	0.	0.	19.46	.52	0.	33.62
631.0	1.15	1.20	0.	12.55	0.	0.	0.	32.51	.55	0.	47.96

632.0	1.15	1.20	0.	13.99	0.	0.	0.	45.57	.58	0.	62.49
633.0	1.25	1.20	0.	15.05	0.	0.	0.	58.62	.64	0.	76.76
634.0	1.80	1.80	0.	17.58	0.	0.	0.	71.68	.71	0.	93.56
635.0	1.80	1.80	0.	21.28	0.	0.	0.	216.32	.89	0.	242.09
636.0	1.80	1.80	0.	25.24	0.	0.	0.	335.36	.95	0.	365.15
637.0	1.80	1.80	0.	27.88	0.	0.	0.	426.24	1.04	0.	458.76
638.0	1.80	1.80	0.	29.96	0.	0.	0.	472.32	1.13	0.	507.01
639.0	1.85	1.80	0.	31.25	0.	0.	0.	509.13	1.21	0.	545.24
640.0	1.90	1.80	0.	32.23	0.	0.	0.	541.25	1.28	0.	578.47
616.7 (2 YEAR)	.20	.70	0.	0.	0.	0.	0.	0.	.12	0.	1.02
623.5 (10 YEAR)	.45	.90	0.	0.	0.	0.	0.	0.	.32	0.	1.67
624.0 (20 YEAR)	.55	1.10	0.	0.	0.	0.	0.	0.	.33	0.	1.98
625.6 (50 EAR)	.55	1.10	0.	0.	0.	0.	0.	0.	.40	0.	2.05
627.1 (100 YEAR)	.70	1.20	0.	0.	0.	0.	0.	0.	.43	0.	2.33

DAMAGE CATEGORY	LAND USE CODE	LAND USE
1	1	NATURAL VEGETATION
2	2	DEVELOPED OPEN SPACE
3	3	LOW DENSITY HOUSING
4	4	MEDIUM DENSITY HOUSING
5	5	HIGH DENSITY HOUSING
6	6	AGRICULTURE
7	7	INDUSTRIAL
8	8	COMMERCIAL
9	9	PASTURE
10	10	WATER BODIES

SAMPLE PROBLEM
UTILIZING FLOOD PLAIN REGULATION, FLOOD PROOFING,
AND EVACUATION
DAMAGE REACH NO. 3

EXHIBIT 4-6
JANUARY 1979

DAMAGE REACH 3-LAST SECTION OF WEST FORK

LAND USE CATEGORIES

WATER SURFACE ELEVATION	1	2	3	4	5	6	7	8	9	10	TOTAL
695.0	.60	0.	0.	0.	0.	0.	0.	0.	0.	0.	.60
696.0	.70	0.	0.	0.	0.	0.	0.	0.	0.	0.	.70
697.0	.75	0.	0.	0.	0.	0.	0.	0.	0.	0.	.75
698.0	.75	0.	0.	0.	0.	0.	0.	0.	0.	0.	.75
699.0	.80	0.	0.	0.	0.	0.	0.	0.	0.	0.	.80
700.0	.85	0.	0.	0.	0.	0.	0.	0.	0.	0.	.85
701.0	.90	0.	0.	0.	0.	0.	0.	0.	0.	0.	.90
702.0	.95	0.	0.	0.	0.	0.	0.	0.	0.	0.	.95
703.0	1.00	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.00
704.0	1.05	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.05
705.0	1.05	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.05
706.0	1.15	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.15
707.0	1.25	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.25
708.0	1.35	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.35
709.0	1.45	0.	0.	0.	0.	0.	0.	0.	.00	0.	1.45
710.0	1.60	0.	0.	0.	0.	0.	0.	0.	.02	0.	1.62
710.8	1.95	0.	0.	0.	0.	0.	0.	0.	.03	0.	1.98
711.0	1.95	0.	0.	0.	0.	.01	0.	0.	.03	0.	1.99
711.9	2.10	0.	0.	0.	0.	.04	0.	0.	.06	0.	2.19
712.0	2.10	0.	0.	0.	42.42	.04	0.	0.	.06	0.	44.62
713.0	2.30	0.	0.	0.	120.96	.05	0.	0.	.07	0.	123.38
714.0	2.80	0.	0.	0.	165.66	.06	0.	0.	.09	0.	168.61
715.0	3.20	0.	0.	0.	200.76	.15	0.	0.	.15	0.	204.26

716.0	3.55	0.	0.	0.	278.10	.24	0.	0.	.19	0.	282.06
717.0	3.70	0.	0.	0.	342.90	.29	0.	0.	.23	0.	347.12
718.0	3.80	0.	0.	0.	395.22	.33	0.	0.	.27	0.	399.62
719.0	4.00	0.	0.	0.	443.52	.36	0.	0.	.33	0.	448.22
720.0	4.15	0.	0.	0.	471.72	.39	0.	0.	.42	0.	476.68
721.0	4.20	0.	0.	0.	533.46	.41	0.	0.	.47	0.	538.54
722.0	4.25	0.	0.	0.	582.90	.41	0.	0.	.54	0.	588.10
723.0	4.60	0.	0.	0.	624.72	.41	0.	0.	.59	0.	630.32
724.0	4.75	0.	0.	0.	706.26	.45	0.	0.	.65	0.	712.11
725.0	5.10	0.	0.	0.	837.66	.50	0.	0.	.75	0.	844.00
708.6 (2 YEAR)	1.40	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.40
710.2 (10 YEAR)	1.60	0.	0.	0.	0.	0.	0.	0.	.02	0.	1.62
710.8 (20 YEAR)	1.95	0.	0.	0.	0.	0.	0.	0.	.03	0.	1.98
711.5 (50 YEAR)	2.05	0.	0.	0.	0.	.03	0.	0.	.05	0.	2.12
711.9 (100 YEAR)	2.10	0.	0.	0.	0.	.04	0.	0.	.06	0.	2.19

DAMAGE CATEGORY	LAND USE CODE	LAND USE
1	1	NATURAL VEGETATION
2	2	DEVELOPED OPEN SPACE
3	3	LOW DENSITY HOUSING
4	4	MEDIUM DENSITY HOUSING
5	5	HIGH DENSITY HOUSING
6	6	AGRICULTURE
7	7	INDUSTRIAL
8	8	COMMERCIAL
9	9	PASTURE
10	10	WATER BODIES

EXHIBIT 4-7

INPUT DESCRIPTION

DAMAGE REACH STAGE-DAMAGE CALCULATION
PROGRAM NAME - DAMCAL

EXHIBIT 4-7

INPUT DESCRIPTION

DAMAGE REACH STAGE-DAMAGE CALCULATION

PROGRAM NAME - DAMCAL

This exhibit provides a detailed description of the DAMCAL data input requirements, card by card and variable by variable.

The field number designates the location of the variables on each input card. Card columns 1-2 are reserved for the card identifiers and are referred to as Field 0. Field 1 ranges from card columns 3-8; Fields 2-10 contain eight card columns each. An abbreviated field location nomenclature is used to identify the field location. The card name is followed by a decimal point and the field number. For example, LU.8 refers to the eighth field on the LU card. All variables beginning with I, J, K, L, M, and N should have integer values (no decimal point) and be right-justified (the values shifted to the right within each field). A "+" sign under the value heading indicates the placement of a positive numerical value in that field. A "-" sign indicates a negative numerical value in that field. "AN" means that a combination of alphanumeric characters is allowed. The variable value of zero should be keypunched on the card, as a blank field on some computer systems will be read as a negative zero which may cause logic problems in the software. When a number does not have a sign, a positive value will be assumed.

TITLE CARDS

T1, T2, T3 Cards: (Required Cards)

These cards provide up to three lines of information at the top of each page of output.

Field	Variable	Value	Description
0	CODE	T1, T2 or T3	Card identification (3 cards)

T1, T2, T3 Cards (continued)

Field	Variable	Value	Description
1-10	TITLE	AN	Title information (center of title falls in card column 41).

JOB CARDS

J1 Card: First Job Card (Required Card)

This card describes the type of analysis to be performed, the printout option and the file management option.

Field	Variable	Value	Description
0	CODE	J1	Card identification
1	IPOL	0	Land use under analysis is the base condition.
		1	Land use under analysis is a modified or projected land use pattern. Zero stage of all specified land use categories to be raised above the specified flood level (J4 and DR cards).
		2	Land use under analysis is a modified or projected land use pattern. All specified new development to be located such that the zero stage is above a specified flood level (J4 and DR cards).
		3	Land use under analysis is a modified or projected land use pattern. All specified land uses to be located such that the zero damage elevation (the highest elevation for a grid cell exhibiting no damage) is above a specified flood level (J4 and DR cards).
		4	Land use under analysis is a modified or projected land use pattern. All specified new development to be located such that the zero damage elevation (the highest elevation for a grid cell exhibiting no damage) is above a specified flood level (J4 and DR cards).

J1 Card: First Job Card (Continued)

Field	Variable	Value	Description
2	IPROF	0	No flood proofing is required in this computer run.
		1	All indicated land use categories are flood proofed to a specified depth with reference to the zero stage (J5 and J6 cards).
		2	Only new development of indicated land use categories are floodproofed to a specified depth with reference to the zero stage (J5 and J6 cards).
		3	All indicated land use categories are floodproofed to a specified protection level flood event (J5 and DR cards).
		4	Only new development of indicated land use categories are floodproofed to a specified protection level flood event (J5 and DR cards).
3	IEVAC	0	No permanent evacuation.
		1	Permanent evacuation of specified land use categories which have a zero stage elevation in the restricted flood plain (J7 and DR cards).
		2	Only new development of indicated land use categories which have a zero stage elevation in the restricted flood plain are permanently evacuated (J7 and DR cards).
		3	Permanent evacuation of specified land use categories which have a zero damage elevation (the highest elevation for a grid cell exhibiting no damage) in the restricted flood plain (J7 and DR cards).
		4	Only new development of indicated land use categories which have a zero damage elevation (the highest elevation for a grid cell exhibiting no damage) in the restricted flood plain are permanently evacuated (J7 and DR cards).

J1 Card: First Job Card (continued)

Field	Variable	Value	Description
4	IEVCLU	+	The land use category into which permanently evacuated grid cells are transformed. A value should be specified when IEVAC (J1.3) is greater than zero. If blank or zero, a zero damage potential is assumed for the evacuated grid cell.
5	IPRNT	0	Normal printout.
		1	Suppress land use economic printout.
6	ITRACE	0	Suppress trace printout.
		1	Trace output is requested (J8 card).
7	IAUTO	0	No ATODTA input file is created
		1	Create input damage file for ATODTA (Tape 20 should be saved at end of execution).
8	ITYPE	0	Aggregated elevation-damage curves only.
		+	Number of single flood event damages calculated (maximum of 10).
9	IAG	0	No single flood event aggregation
		1	Aggregate single flood event (LU.10 & DR.8).

J2 Card: Second Job Card (Required Card)

This card describes the location of the data bank, the number of data variables, the dimensions of the data base, and whether or not the grid cell data bank is formatted.

Field	Variable	Value	Description
0	CODE	J2	Card identification
1	NFILE	1	The DATA BANK is located on input unit 1.
		5	The DATA BANK is on computer cards.
2	NFORM	0	The DATA BANK is unformatted.
		1	The DATA BANK is formatted.

J2 Card: Second Job Card (continued)

Field	Variable	Value	Description
3	NDV	+	The number of data variables in the DATA BANK.
4	IROW	+	The number of rows in the DATA BANK.
5	ICOL	+	The number of columns in the DATA BANK.
6	IMAGE	0	No input card images are provided.
		1	Input card images are provided at the beginning of the output.

J3 Card: Third Job Card (Required Card)

C

This card defines the sequence numbers of the data variables used in the analysis and the number of categories for particular data variables.

Field	Variable	Value	Description
0	CODE	J3	Card identification
1	IDAMRC	+	The sequence number of the damage reach variable.
2	NODR	+	The number of damage reaches in the analysis.
3	ILAND	+	The sequence number of the land use variable to be analyzed. (This will be the base condition if IBASE (J3.4) = 0 or the alternative future condition if IBASE is positive).
4	IBASE	0	The base condition is analyzed.
		+	The sequence number of the land use variable that is the base condition for locating new development.
5	NOLUC	+	The number of land use categories in ILAND (J3.3).
6	ITOPO	+	The sequence number of the topography elevation variable.
7	IRFED	+	The sequence number of the reference flood elevation variable.
8	IELV	+	The number of elevations to be calculated for the elevation-damage relationships.

J4 Card: Fourth Job Card (Optional Card)

The J4 card(s) is used when IPOL (J1.1) is greater than zero. Up to three J4 cards can be used. If the last J4 value input is JPOL (10) or JPOL (20), then a blank J4 card must follow. The order in which land use categories are input is not important.

Field	Variable	Value	Description
0	CODE	J4	Card identification
1	JPOL(1)	+	Land use category to be raised above the specified flood elevation.
2	JPOL(2)	+	Etc., up to a maximum of 30 land use categories.

J5 Card: Fifth Job Card (Optional Card)

The J5 card(s) is used when IPROF (J1.2) is greater than zero. Up to three J5 cards can be used. If the last J5 value input is JPRF(10) or JPRF (20) then a blank J5 card must follow. The order in which land use categories are input is not important.

Field	Variable	Value	Description
0	CODE	J5	Card identification
1	JPRF(1)	+	Land use category to be floodproofed.
2	JPRF(2)	+	Etc., up to a maximum of 30 land use categories.

J6 Card: Sixth Job Card (Optional Card)

The J6 card(s) is used when IPROF (J1.2) = 1 or 2. The depth of floodproofing is in reference to the zero stage and the order of input must correspond to the appropriate J5 card value. Up to three J5 cards can be used. If the last J6 value input is DROF(10) or DROF(20) then a blank J6 card must follow.

Field	Variable	Value	Description
0	CODE	J6	Card identification
1	DROF(1)	+	Depth of floodproofing for the land use category indicated in J5.1.
2	DROF(2)	+	Etc., up to a maximum of 30 land use categories.

J7 Card: Seventh Job Card (Optional Card)

An optional card(s) used to specify land use categories that will be permanently evacuated. Up to three J7 cards can be used. If the last J7 value input is JEVAC(10) or JEVAC(20) then a blank J7 card must follow. The order in which land use categories are input is not important.

Field	Variable	Value	Description
0	CODE	J7	Card identification
1	JEVAC(1)	+	Land use category to be permanently evacuated.
2	JEVAC(2)	+	Etc., up to a maximum of 30 land use categories.

J8 Card: Eighth Job Card (Optional Card)

This is an optional card used only when ITRACE (J1.6) = 1.

Field	Variable	Value	Description
0	CODE	J8	Card identification
1	NNDR	+	Damage reach to be traced. Should correspond to a value JDR(I), on the (or a) DR card.
2	NNLU	+	Land use category to be traced within the damage reach indicated above.

FT Card: Format Card (Optional Card)

This card is used only when the data bank is formatted, NFORM (J2.2) = 1. A set of parenthesis is needed to inclose the format statement.

Column	Variable	Value	Description
1-2	CODE	FT	Card identification
3-80	FMT(I)	(AN)	The format description must have a left parenthesis in card column 3. The description of the format must be in a fixed point format. The end of the format must be followed with a right parenthesis.

ST Card: Single Flood Event Title Card (Optional Card)

This card required only when single flood event analysis is performed, ITYPE (J1.8) is positive. ITYPE number of values are input, up to a maximum of ten (10).

ST Card (continued)

Field	Variable	Value	Description
0	CODE	ST	Card identification
1	SEVTIT(1)	AN	Title of first flood event.
2	SEVTIT(2)	AN	Etc., ITYPE(I) items.

COMPOSITE LAND USE CARDS

One set of Composite Land Use Cards (LU, LT, DF, DS, DC, DO, DD) is needed for each land use category included within ILAND (J3.3).

LU Card: Land Use Damage Card (Required Card)

NOLUC (J3.5) number of LU cards are required.

Field	Variable	Value	Description
0	CODE	LU	Card identification
1	LUC	+	Land use category number.
2	INPET	0	DD cards are used.
		1	DS, DC and DO cards are used.

*** If INPET = 0, fields 3 through 7 on this card should reflect the values used to calculate the composite stage damage values input on the DD cards.

Field	Variable	Value	Description
3	DENSITY	+	Number of damageable units per grid cell.
4	BASEVAL	+	Average dollar value of the structure.
5	BASEVLU	+	Average dollar value of the contents.
		0	No content value.
		-	Percent of structure value that is used to calculate the value of the contents (30% is recorded as -.30).
6	BASEIND	+	Dollar value of other damages.
		0	No value.
		-	The value input on the DO card is used to calculate other damages.

LU Card (continued)

Field	Variable	Value	Description
7	VACNCY	+	The percent of developed land within the grid cell (80% is recorded as .80). The default value = 100%.
8	NDAM	+	The number of depth values to be read on the DF cards up to a maximum of 30 values.
9	IPROT	0	Normal printout
		1	Suppress composite damage printout for this land use type.
10	IAGGLU(I)	+	Used only when IAG (J1.9) = 1. The value will be the sequence number of the new land use category created by the aggregation of the land use category in LUC. (Several LUC, land use categories, can be combined into a single new land use category). The specified new values must be in sequence starting with 1 up to a maximum specified value of 10.

LT Card: Land Use Title Card (Required Card)

This card is used for the zero stage adjustment and land use title.

Field	Variable	Value	Description
0	CODE	LT	Card identification
1	LUCT	+	Land use category on preceding LU card.
2	DEPADJ	0	The zero stage of the composite damage function and the grid cell elevation in the DATA BANK are both based on the ground elevation.
		+ or -	Depth of flooding adjustment (in feet) made to the stages of the composite damage function when the zero stage is not based on ground elevation. (Used only when the zero stage of the composite damage curves are based on a first floor datum that is different than the corresponding ground datum). A positive value would indicate a first floor level above the corresponding ground level.

LT Card (continued)

Field	Variable	Value	Description
3-8	TITLU	AN	Title of land use category.

DF Card: Depth of Flooding Card (Required Card)

There is a maximum of three DF cards per land use. There must be NDAM (LU.8) number of values on this card or cards.

Field	Variable	Value	Description
0	CODE	DF	Card identification
1-10	DEPTH(I)	+ or -	The depth of flooding values for the stage-damage curve. If more than 10 stages, the eleventh value is placed in field 1 of the next DF card.

DS Card: Damage to Structure Card (Optional Card)

The DS card is used if INPUT (LU.2) = 1. The card values must be input in the same order as the corresponding depth of flooding values on the DF card(s), NDAM (LU.8) values. (The DD card must be input if this card is not used).

Field	Variable	Value	Description
0	CODE	DS	Card identification
1-10	DS(I)	0 or +	The percent of damage to the structure which corresponds to the depth of flooding on the DF card (30% is input as 30).

DC Card: Damage to Contents Card (Optional Card)

An optional card(s) in which the values must be input in the same order as the corresponding depth of flooding values on the DF cards, NDAM (LU.8) values. The DC card is needed in conjunction with the DS card.

Field	Variable	Value	Description
0	CODE	DC	Card identification
1-10	DC(I)	0 or +	The percent of damage to the contents which corresponds to the depth of flooding on the DF card (30% is input as 30).

DO Card: Other Damages Card (Optional Card)

An optional card(s) in which the values must be input in the same order as the corresponding depth of flooding vlaues on the DF cards, NDAM (LU.8) values. The DO card is needed in conjunction with the DC and DS cards.

Field	Variable	Value	Description
0	CODE	DO	Card identification
1-10	DO(I)	0 or +	The percent of damage to structure and contents (corresponding to DF values) that reflects other damages (30% is recorded as 30). If LU.6 is positive, DO(I) is the percent of LU.6 that then represents other damages.

DD Card: Total Damage Card (Optional Card)

Field	Variable	Value	Description
0	CODE	DD	Card identification
1-10	DAMAGE(I)	+	Total dollar damages for the corresponding depth of flooding value on the DF card (in thousands of dollars).

DAMAGE REACH CARDS

One set of Damage Reach Cards (DR, DT, SE, LC) is needed for each damage reach indicated, NODR (J3.2).

DR Card: Damage Reach Card (Required Card)

Field	Variable	Value	Description
0	CODE	DR	Card identification
1	JDR(I)	+	Damage reach identification code.
2	REFFLD(I)	+	The reference flood water surface elevation (WSE) at the index location.
3	POLELV(I)	+	Used only if IPOL (J1.1) is greater than zero. The water surface elevation (WSE) at the index location indicating the policy level above which all specified development is to be built.
4	PROELV(I)	+	Used only when IPROF (J1.2) = 3 or 4. The water surface elevation (WSE) at the index location which corresponds to the protection level flood event.

DR Card (continued)

Field	Variable	Value	Description
5	EVCELV(I)	+	Used only if IEVAC (J1.3) is greater than zero. The water surface elevation (WSE) at the index location which corresponds to the evacuation flood event.
6	STRELV(I)	+	The water surface elevation (WSE) at the index location where the aggregated elevation-damage function is to begin (the minimum elevation for computational purposes).
7	ELINTR(I)	+	Increment (in feet) between water surface elevations used in the computation (or aggregation) of damages.
8	IAGGDR(I)	+	Used only when IAG (J1.9) = 1. The value will be the sequence number of the new damage reach created by the aggregation of the damage reach in JDR. (Several JDR, damage reaches, can be combined into a single new damage reach). The specified new values must be in sequence starting with 1.
9	IMODFY	0	No modification to land use category density, structure value, content value and other value as originally input.
		+	The number of land use categories to be modified in the current damage reach, JDR (DR.1).

DT Card: Damage Reach Title Card (Required Card)

Field	Variable	Value	Description
0	CODE	DT	Card identification
1-10	DTITLE(I)	AN	Description of damage reach on preceding DR card, (DR.1).

SE Card: Single Flood Event Card (Optional Card)

The SE card is necessary only for single flood event analysis, ITYPE (J1.8) is positive. Use ITYPE (J1.8) number of values.

SE Card (continued)

Field	Variable	Value	Description
0	CODE	SE	Card identification
1	SINGLE(1,I)	+	The water surface elevation at the index location of the current damage reach for the first flood event, SEVTIT(1), indicated on the ST card.
2	SINGLE(2,I)	+	The water surface elevation at the index location of the current damage reach for the second flood event, SEVTIT(2), indicated on the ST card.
.	.	.	
.	.	.	
.	.	.	
.	.	.	
10	SINGLE(10,I)	+	The water surface elevation at the index location of the current damage reach for the tenth flood event, SEVTIT(10), indicated on the ST card.

LC Card: Change to Land Use Category Damage Functions (Optional Card)

This card(s) is needed when IMODFY (DR.9) is greater than zero. If this card is used, the complete damage data for the modified land use categories within the current damage reach must be input (fields 1 through 6 must contain coded values). IMODFY number of LC cards should be used.

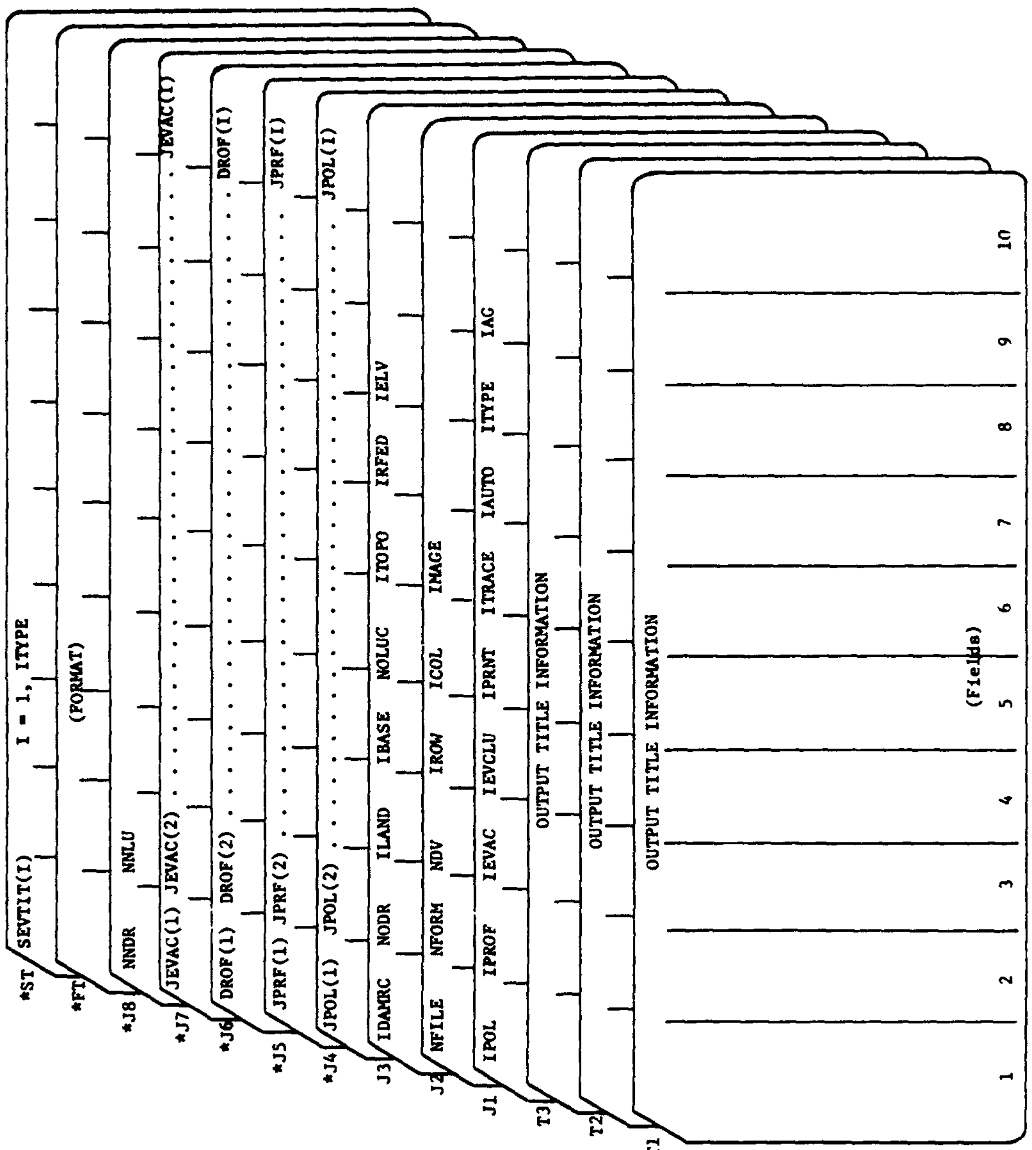
Field	Variable	Value	Description
0	CODE	LC	Card identification
1	LUCC	+	Land use category number.
2	DENSTYC	+	Number of damageable units per grid cell.
3	BSEVALC	+	Average dollar value of structure.
4	BSEVLUC	+	Average dollar value of the contents.
		-	The percent of structure value that is used to calculate the value of the contents (30% is recorded as -.30).

LC Card (continued)

Field	Variable	Value	Description
5	BSEINDC	+	Dollar value of other damages.
		-	The percent of total damages that is used to calculate other damages (30% is recorded as -.30).
6	VACNCYC	+	The percent of developed land within the grid cell (80% is recorded as .80).

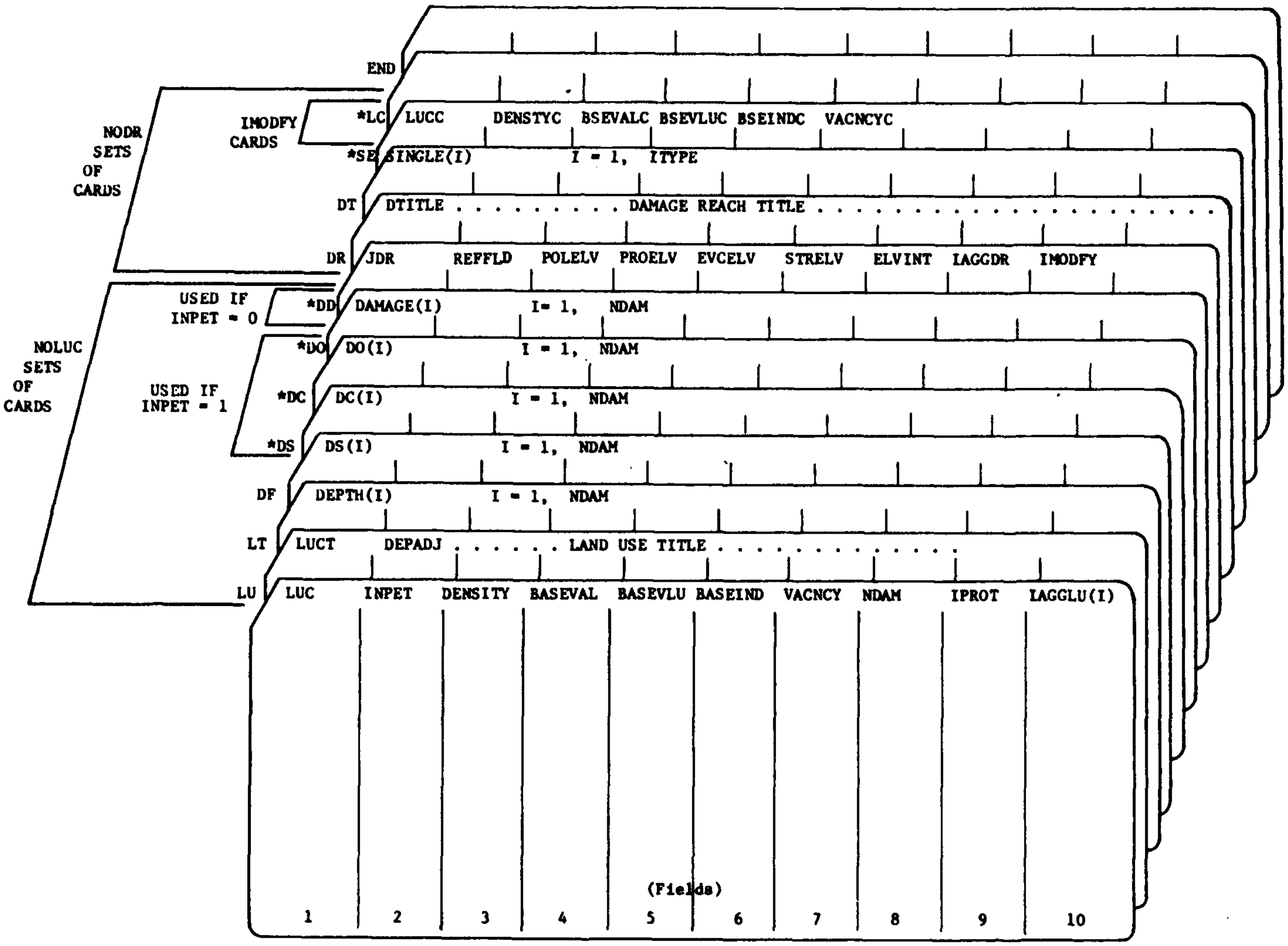
END Card: Ending Card (Required Card)

Field	Variable	Value	Description
0	CODE	END	Signals end of input data. This card should follow the DATA BANK when NFILE (J2.1) = 5.



* Optional Card

DAMCAL CARD STREAM



* Optional Card

DAMCAL CARD STREAM (continued)